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Residential Customer Behavioral Savings Pilot Evaluation

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Executive Summary

The Vermont Public Service Department (PSD) contracted with Cadmus to evaluate the Efficiency Vermont (EVT) Residential Customer Behavioral Savings (RCBS) Pilot. Starting in November 2014, Opower (now Oracle Utilities Opower), the RCBS Pilot implementer, delivered home energy reports (HERs) to residential customers of Green Mountain Power. The HERs provided energy efficiency education and tips to encourage customers to reduce their energy consumption. The PSD tasked Cadmus with estimating the RCBS Pilot's electricity savings, identifying behavior changes and energy efficiency improvements caused by the HERs, assessing customer satisfaction with the HERs, and assessing the program cost-effectiveness.

In December 2017, Cadmus delivered an RCBS Pilot evaluation report with 2016 findings and recommendations to the PSD. The report covered the pilot from January 2016 to December 2016, with separate analyses of savings for the original treatment group (Wave 1) and a refill group (Wave 2).[1] The evaluation revealed that the RCBS Pilot saved 1.3% of consumption, increased participation in EVT upstream and downstream rebate programs, and was cost-effective. In addition, while customer satisfaction with HERs remained high, some customers found fault with the accuracy of the neighbor comparison.

In 2017, EVT redesigned the HERs and emails to remove the neighbor comparisons, to focus on providing personalized energy-savings analyses and energy-saving tips, and to rebrand the reports as Current Insights. EVT decided to remove the social-normative neighbor comparison in response to complaints from customers about the accuracy of the comparisons. EVT also added a third pilot wave (Wave 3) of approximately 12,400 treatment group customers and 8,700 control group customers to account for participant attrition due to customer account closures. EVT delivered HERs to approximately 105,000 customers in 2017.

This evaluation report covers the program year from January to December 2017, with impact findings for the three waves that tracks the progress of the Wave 1 and Wave 2 treatment groups since they first received HERs.

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[1] In 2016, Cadmus submitted an evaluation report for the 2014 and 2015 program years. Cadmus. *Final Report: Evaluation of Residential Customer Behavioral Savings Pilot*. Prepared for Vermont Public Service Department. September 7, 2016. Available online: http://publicservice.vermont.gov/sites/dps/files/VT%202015%20HER%20Behavior%20Pilot%20Evaluation%20Report.pdf

Research Objectives

For the 2017 evaluation, Cadmus investigated several research questions:

- **Energy savings:** What impacts did the RCBS Pilot have on household electricity consumption in 2017? Do savings differ between high, medium, and low consumption customers? Do savings differ between regular-income and low-income[2] customers? What are the trends in savings since customers first received HERs? What effect did removing the neighbor comparison have on electricity savings?
- **Energy efficiency program participation uplift:** What impact did the RCBS Pilot have on participation in EVT's downstream energy efficiency programs? Did receiving HERs increase the adoption of LEDs? What percentage of RCBS Pilot savings are attributable to participation in EVT energy efficiency programs?
- **Cost-effectiveness:** Was the RCBS Pilot cost-effective in 2017 and from 2014 to 2017? What was the levelized average cost of saved electricity?
- **Savings persistence and measure life:** What does the literature on HER savings persistence and measure life indicate? Does the literature have relevance for Vermont? What does the trend in savings during the pause in HER delivery in March 2015 reveal about HER savings persistence and measure life? How could EVT implement a study to estimate savings persistence and measure life?

Cadmus conducted several research activities to answer the research questions:

- **Document review:** Review of Opower and EVT program implementation documents
- **Customer surveys:** Surveys of treatment and control group customers
- **Energy-savings analysis:** Regression analysis of Green Mountain Power monthly customer electricity bills
- **Efficiency program uplift analysis:** Analysis of energy efficiency program participation and customer survey data to estimate HER impacts on program participation
- **Cost-effectiveness analysis:** Analysis of the benefits and costs of the RCBS Pilot using the Vermont 2017 Statewide Screening Tool
- **Savings persistence:** Analysis of applicability to Vermont of savings persistence and measure life findings from studies of other HER programs and recommendations about HER measure life for Vermont

Key Findings

This section presents key findings, conclusions and recommendations regarding energy savings, efficiency program uplift, savings persistence and measure life, and program cost-effectiveness.

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[2] EVT defined low income using Vermont 2015 Criteria based on household income and size: low income flag if (1 person ≤ $38,900; 2 person ≤ $44,500; 3 person ≤ $50,050; 4 person ≤ $55,600; 5 person ≤ $60,050; 6 person ≤ $64,500; 7 person ≤ $68,950; 8 person ≤ $73,400)

Energy Savings

Although EVT removed the neighbor comparison from the reports in 2017, the RCBS Pilot continued to generate electricity savings. Wave 1 customers saved approximately 1.4% of electricity consumption, while Wave 2 customers saved 0.6% and Wave 3 customers save 0.1%. Across all waves, treated customers saved 1.2% of consumption. The RCBS Pilot saved 9,380 MWh, which was 97% of Opower's forecast of 2017 savings.

Electricity savings in 2017 were essentially unchanged from 2016. Wave 1 savings decreased by 0.1% and Wave 2 savings increased by 0.1% from 2016 through 2017, suggesting that electricity savings reached a steady state. In contrast to previous waves, Wave 3 did not save electricity during the first year of treatment. This lack of Wave 3 savings may be attributable to removing the neighbor comparison from reports in 2017, which meant that Wave 3 customers were not exposed to this form of treatment. There are a couple additional contributing factors:

- Wave 3 included a higher percentage of multifamily homes than Wave 1 or Wave 2, which tend to correlate with lower energy usage in general.
- Approximately 30% of Wave 2 and Wave 3 homes had been previously occupied by different owners who received treatment during Wave 1 or Wave 2. As behavior-based treatments such as HERs cause customers to make lasting energy efficiency improvements, savings from these improvements will persist after customers move out of their homes, limiting the potential for new customers at these residences to save and reducing the pilot's cost-effectiveness.

While the overall electric savings remained unchanged from 2016, there was a clear downward trend in monthly savings during 2017, suggesting diminution of savings. This downward trend in Wave 1 customer savings may be related to removing the neighbor comparison. However, to know with certainty, it would have been necessary to conduct a randomized experiment in 2017, with some randomly selected customers continuing to receive the neighbor comparison.

In 2017, high electricity consumption homes saved the most electricity. In Wave 1, high electricity consumption homes saved an average of 0.57 kWh per day, medium consumption homes saved 0.36 kWh per day, and low consumption homes saved 0.11 kWh per day. Although high consumption homes only accounted for 27% of treated homes in Wave 1, they were responsible for 50% of the savings.

Low-income customers saved as much electricity as regular-income customers. Comparison of Wave 1 low-income and regular-income customers revealed small and statistically insignificant differences in 2017 electricity savings. Low-income and regular-income customers had similar electricity consumption, which appears to have been a more important driver of savings than income.

Recommendation 1: EVT should consider targeting energy reports or other behavior-based treatments to the largest electricity consumers, since on average these customers save the most energy.

Recommendation 2: EVT should consider not enrolling new customers who occupy homes that were previously occupied by customers who received behavior-based treatments.

Efficiency Program Uplift

In 2017, HERs caused customers to participate in EVT's downstream energy efficiency programs and increased pilot electricity savings. HERs increased the rate of participation in the EVT downstream rebate program by 4.6% for Wave 1 customers, 3.7% for Wave 2 customers, and 12.5% for Wave 3 customers. Across the waves, customers receiving HERs were 5.5% more likely to participate.

HERs caused customers to adopt more efficient lighting. In surveys, treated customers reported purchasing 0.7 more LEDs over the previous 12 months than control group customers. The savings attributable to these LED purchases—after adjusting for in-service rates, installation dates, and other factors—was about 532 MWh.

Participation in upstream and downstream EVT programs in 2017 and previous years accounted for about 1,506 MWh, or 15% of the estimated RCBS Pilot savings for 2017. Approximately one-third of the uplift savings are attributable to customer adoption of LEDs. The remaining uplift savings are from customer adoption of measures rebated through EVT's downstream programs.

Recommendation 3: In future behavior-based programs, EVT should continue to market its energy efficiency programs. Behavior-based programs are effective at increasing participation in EVT programs.

Savings Persistence and Measure Life

Studies of HER programs in the United States indicates that electricity savings persist after treatment ends. Many studies of HER programs administered by other utilities have revealed that the average annual rate of savings decay is between 20% and 50% after customers stop receiving HERs, implying an HER measure life of between two and five years. However, some studies found significantly lower rates of savings decay, implying measure life greater than 10 years. The rate of savings decay depends on the frequency and duration of treatment. Customers who receive HERs more frequently and for longer periods of time have lower savings decay rates and longer measure life.

Existing studies of HER savings persistence may not have validity for Vermont. EVT has not conducted a HER savings persistence study. Program administrators of other HER programs have conducted such studies, but the utility service areas have different customer populations. Vermont utility customers tend to consume less electricity on average and have significantly lower penetrations of central air conditioning and electric space heat than customers of other electric utilities. These differences present validity challenges when comparing savings persistence outcomes.

The pause in HER delivery in April 2015 strongly suggest that HER savings persist after treatment ends but that savings decay rapidly if customers have been treated for less than one year. Between April 2015 and August 2015, when report delivery resumed, savings decayed from 1.2% to 0.4%, or at 22% per month. If EVT had not resumed delivery and with this rate of savings decay, the RCBS Pilot would have ceased to save electricity by April 2016.

Recommendation 4: EVT should consider conducting a measure life study based on analysis of utility customer consumption data to develop an accurate measure life assumption for the RCBS Pilot or a new, large behavior-based pilot. This study should be conducted as a randomized control trial (RCT) and the treatment groups should be sized to estimate the expected savings decay rate with sufficient precision.

Recommendation 5: Given substantial uncertainty and lack of empirical evidence about HER measure life in Vermont, EVT should continue to assume a one-year HER measure life. While it is probable that the HER measure life is greater than one year, there remains great uncertainty about the specific measure life and there are too many differences between Vermont utility customers and customers of utilities elsewhere to assume that previous studies of other HER utility programs have validity for Vermont.

Cost-Effectiveness

The RCBS Pilot was cost-effective from 2014 through 2017. Based on the societal cost test (SCT), the RCBS Pilot had a benefit/cost ratio of 1.4 from 2014 to 2017, and of 1.6 in 2017. The pilot continued to be cost-effective in 2017 because the electricity savings remained essentially unchanged from 2016. Cadmus attributed RCBS Pilot savings and costs to the low-income and regular-income customer segments, which helped to lift the pilot cost-effectiveness because of additional non-energy benefits attributable to low income customers.

Recommendation 6: EVT should consider re-evaluating the pilot cost-effectiveness annually. It is expected that the pilot will continue to be cost-effective if savings persist during treatment and there are not significant increases in program implementation costs.

Introduction

Through the RCBS Pilot, EVT delivered HERs to inform residential customers about their home energy use and to encourage energy-efficient behaviors. The PSD had several objectives for the RCBS Pilot:

- Achieve verifiable, cost-effective savings in Vermont
- Increase customer awareness of energy efficiency
- Encourage customers to adopt energy-saving behaviors and measures
- Promote EVT's energy efficiency programs and drive customer participation

The RCBS Pilot does not provide financial incentives to customers for engaging in energy-efficient behaviors, but it does encourage customers to participate in EVT's other energy efficiency programs.

RCBS Pilot Design

EVT administers and Opower implements the RCBS Pilot. From January to December 2017, EVT and Opower delivered over 440,000 HERs to customers. The pilot comprised three waves of customers. The first wave (Wave 1) originally included 105,000 customers who received their first reports in November 2014. Because of attrition due to customer account closures, Wave 1 only included 86,813 customers at the beginning of 2017. EVT added a refill wave (Wave 2) of 12,600 customers in February 2016 and a second refill wave (Wave 3) of 12,393 customers in March 2017. Table 1 shows the RCBS Pilot's design and the number of active customer accounts for 2017 by wave.

Table 1. Residential Customer Behavioral Savings Pilot Design

Group and Use Band	HERs Delivery Frequency in 2017	Number of Customers Assigned to Treatment	Number of Customers in 2017[a]	Average Pre-Treatment Daily Energy Use per Customer (kWh)[b]
Treatment Group				
Wave 1	5 printed HERs; 6 electronic HERs; web portal access	105,000	86,813	21.1
Wave 2		12,600	9,689	19.3
Wave 3		12,393	11,869	11.8
Total Treatment Group		**129,993**	**108,371**	**20.1**
Control Group				
Wave 1	N/A	21,000	17,365	21.1
Wave 2		2,500	1,912	19.4
Wave 3		8,679	8,274	11.7
Total Control Group		**32,179**	**27,551**	**19.3**

[a] Number of customers with active accounts during the 2017 program year.

[b] Cadmus estimated the average daily energy use per customer using customer billing consumption data between November 2013 and October 2014 (Wave 1), February 2015 and January 2016 (Wave 2), or April 2016 and March 2017 (Wave 3).

Opower produced and distributed the HERs to customers via mail, email, and a HER web portal. Each printed report (delivered via mail) contained the customer's household energy consumption data and energy-saving tips. Customers with valid email addresses also received electronic HERs (delivered via email). Additionally, all HER recipients received the option to create an account for accessing the HER web portal to receive more information on saving energy. The reports also cross-promoted energy-efficiency programs offered by EVT, such as residential lighting and home energy audit programs. In addition to producing and distributing the HERs, Opower selected customers eligible for the RCBS Pilot and forecasted and tracked monthly savings.

Opower and EVT designed the RCBS Pilot as a large-scale RCT field experiment, randomly assigning customers to a treatment or control group. Table 1 reports the number of customers assigned to the treatment and control groups for each wave. Treatment group customers received HERs but could opt out at any time. The control group did not receive HERs and provided a baseline for measuring the energy savings. Before the beginning of the RCBS Pilot, and again at the beginning of 2017, Cadmus assisted with implementing the RCT by randomly assigning eligible customers to the treatment and control groups.

Initially, the RCBS Pilot design further stratified Wave 1 customers by three energy usage bands: high, medium, and low. The number of printed HERs delivered over the year differed based on the customer's energy use band, with high users receiving a greater number of HERs. As the 2016 and 2017 refill waves were significantly smaller than the original Wave 1, these refill waves were not stratified by consumption. Thus, all customers in Wave 2 and Wave 3 received the same number of reports and had the same delivery schedule in 2017.

In 2017, Cadmus evaluated the RCBS Pilot for the 2016 program year and presented findings and recommendations to the PSD. For this report, Cadmus evaluated the RCBS Pilot from January to December 2017, focused on impact findings. We also tracked the savings of Wave 1 and Wave 2 customers since they first received HERs.

Methodology

This section describes the research methodologies Cadmus used to conduct the evaluation.

To answer research questions addressing program delivery, performance, and customer response, Cadmus conducted staff interviews, customer surveys, and a document review. We also conducted a customer billing regression analysis to estimate RCBS Pilot energy savings. This analysis included a review of EVT's energy efficiency programs tracking database, which allowed Cadmus to estimate the RCBS Pilot's impact on participation in EVT's efficiency programs.

In addition, Cadmus reviewed the literature on HER savings persistence and measure life and assessed the validity of this literature's findings for Vermont.

Finally, we conducted an analysis to assess the cost-effectiveness of the RCBS Pilot.

Document Review

Cadmus reviewed examples of the initial welcome letter, the Current Insights reports for each month, the emails delivered in November and December, the report delivery schedule, and the Vermont 2017 Statewide Screening Tool.

Customer Surveys

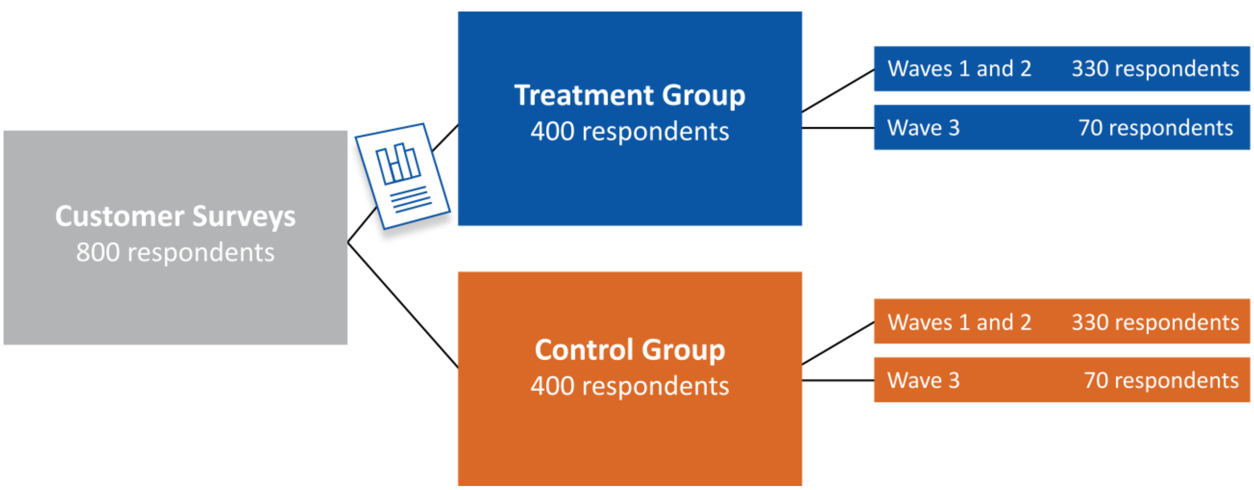
Cadmus worked with the PSD and EVT to adjust the survey instrument used in previous evaluations for changes to the report design and to remove questions that were less essential for the impact evaluation. The survey instrument enabled comparisons between treatment and control group customers and allowed Cadmus to test for differences between customer subsegments (such as homeownership status and energy use strata). The survey also asked questions to evaluate energy-saving behaviors, energy-efficient home improvements, and satisfaction with the HERs.

To assess the HERs' influence, the survey included questions about energy-saving improvements and energy conservation behaviors. Cadmus designed the survey to test a hypothesis that customers who received the HERs would report higher levels of energy-saving investments and behaviors than control customers because of the HERs. The survey questions about types and frequencies of energy-saving improvements and behaviors also provided insight into the HERs influence on the adoption of specific energy-saving measures. *Appendix A* contains a copy of the RCBS Pilot survey instrument.

Using the customer records provided by EVT, Cadmus selected 15,000 customers for the survey sample frame. The Center for Research and Public Policy used the sample to survey 806 Vermont residents, with 401 who had received HERs (treatment) and 405 who had not (control).

Figure 1 shows the survey sample design and the number of survey respondents.

Figure 1. Customer Survey Sample Design and Sample Size Targets



Cadmus compared proportion and mean responses between treatment and control groups and between waves and assessed the statistical significance of differences with t-tests at the 5% ($p \leq 0.05$) and 10% ($p \leq 0.10$) levels.

Energy-Savings Analysis

Cadmus estimated the 2017 RCBS Pilot's impact on energy consumption and participation in EVT's residential energy efficiency programs. We followed evaluation methods prescribed in the U.S.

Department of Energy's *Uniform Methods Project* (UMP)[3] and State and Local Energy Efficiency Action Network Protocol.[4]

Similar to previous evaluations, Cadmus assisted with implementing an RCT for eligible Wave 3 customers by randomly assigning them to the Wave 3 treatment or control group and verifying that these groups were balanced before 2017. For this evaluation, Cadmus did not conduct an evaluation of the RCBS Pilot electricity savings during ISO-New England summer and winter peak hours, as we had done as part of the 2014-2015 and 2016 pilot evaluations.

Pilot Design Verification

In December 2016, Cadmus randomly assigned approximately 21,000 customers eligible for the RCBS Pilot to a Wave 3 treatment group or control group. EVT added customers to the pilot to replace customers in Wave 1 or Wave 2 whose accounts had become inactive in 2016. Per an agreement between the PSD, EVT, and Opower, Cadmus produced five different random assignments of eligible customers to the treatment group or control group, and Opower selected the most balanced sample according to statistical tests.[5] Cadmus verified that all five sets of randomized customers were closely balanced in terms of pre-treatment energy use and concluded that selecting any of the five randomized samples would result in a valid research design. As the third-party, independent evaluator, Cadmus performed this task to avoid any perceived conflicts of interest with the randomization, as recommended in the U.S. Department of Energy's and State and Local Energy Efficiency Action Network's behavior-based program evaluation guidelines.

Table 2 shows the counts of Wave 3 customers assigned to the treatment and control groups. Approximately 12,400 or 59% of customers were assigned to the treatment group and 8,700 customers or 41% were assigned to the control group. The Wave 3 refill group should be large enough to detect the expected savings through analysis of monthly customer billing consumption data.

Table 2. Random Assignment of Customers to Wave 3 Treatment and Control Groups

Energy Use Group	Treatment Group	Control Group	Total
Total	12,393	8,679	21,072

During the group assignment for this evaluation, Cadmus verified that the Wave 3 control and treatment customers showed no large or statistically significant differences in pre-program mean consumption. Table 3 shows the results of this test. The difference in average daily consumption per customer was only

3 National Renewable Energy Laboratory. "Chapter 17: Residential Behavioral Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. January 2017. Available online: https://www.nrel.gov/docs/fy17osti/68573.pdf

4 State and Local Energy Efficiency Action Network. *Evaluation, Measurement, and Verification of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. May 2012. Available online: https://www4.eere.energy.gov/seeaction/system/files/documents/emv_behaviorbased_eeprograms.pdf

5 Opower based the tests on proprietary customer data not available to Cadmus.

0.10 kWh, and the 95% confidence interval for the difference between the two groups includes zero, indicating the difference is not statistically significant at the 5% level.

Table 3. Pre-Program Consumption of Wave 3 Treatment and Control Groups

Group	Pre-Program Average Daily Usage (kWh)	95% Confidence Interval	
		Lower Bound	Upper Bound
Control	11.65	11.56	11.74
Treatment	11.75	11.67	11.82
Difference	**-0.10**	**-0.22**	**0.01**

Data Collection

For the 2017 impact evaluation, Cadmus collected the following data:

- Monthly energy consumption bills between November 2013 and December 2017 for all treatment group and control group customers in Wave 1, Wave 2, and Wave 3
- Customer program tracking data showing wave, assignment to treatment or control group, date of first report, and date of account becoming inactive (if applicable)
- EVT energy efficiency program participation data between November 2014 and December 2017
- Daily weather data for 17 weather stations located in Vermont, New Hampshire, and Massachusetts between November 2014 and December 2017

Customer Monthly Billing Data Preparation

Cadmus performed several steps to clean the customer billing consumption data:

1. Adjusted customer billing consumption for estimated reads[6]
2. Dropped each customer's first and last bill[7]
3. Dropped bills with average daily consumption over 300 kWh or less than -300 kWh
4. Excluded customers whose accounts had become inactive before November 1, 2014, when Opower generated the first HER

6 The first non-estimated bill after an estimated bill contains consumption during the non-estimated period and an estimated correction. Because the non-estimated bills' usage value contains consumption from the previous estimated bills, Cadmus combined any estimated bills with the first following non-estimated bill. For example, if an estimated bill spanned September 15 to October 15, and was followed by a non-estimated bill for October 16 to November 16, we summed usage across both bills, resulting in one bill spanning from September 15 through November 16.

7 A customer's first and last bills may start or end at any point during a calendar month, meaning that the calendar month during which a customer's first bill begins or last bill ends may not cover electricity consumption for all days during the month.

To prepare the cleaned data for regression analysis, we performed the following steps:

1. Calculated heating degree days (HDDs) and cooling degree days (CDDs) for each customer billing cycle using daily mean temperature data and a base temperature of 65°F
2. Allocated customer billing consumption, HDDs, and CDDs to calendar months so that observations in the panel data corresponded to a customer's consumption during a calendar month
3. Removed any observations that were missing one or more days in the month
4. Merged customer program participation data
5. Expressed consumption, HDDs, and CDDs as daily averages for the month

Although most of these data preparation steps were the same as those we had performed in previous evaluations, we discovered changes in the 2017 billing consumption data that required new data cleaning approaches. Specifically, Green Mountain Power used a different method to calculate the number of days in billing cycles after May 2017. In previous years of the RCBS Pilot, we had calculated the start date for each bill by subtracting the number of days in the bill from the billing date and adding one day. This method had resulted in gapless bills for most customers, where the start date was the day after the meter read date of the preceding bill. However, we found that from May 2017 onward, most of the bills' days-in-bill entries included the day of the meter reading. To calculate the start date for these bills, we no longer needed to add one day after subtracting the number of days in the bill from the billing date. Additionally, this change in days-in-bill reporting after May 2017 was not consistent across all customers: for a minority, the days-in-bill field continued to exclude the day of the metering reading.

Moreover, the days-in-bill had been retrospectively adjusted for some customers. For example, one customer's November 2016 bill showed a bill duration of 33 days in the raw data we received for the 2017 evaluation but had a bill duration of 34 days in the raw data we received in 2016 for the 2016 evaluation. Given these issues, we changed our methodology to calculate each bill's start date dynamically:

- For bills occurring before May 2017, we calculated the start date by subtracting the number of days in the bill, minus one or two days—whichever resulted in a start date on the day after the previous bill's read date
- For bills occurring during or after May 2017, we calculated the start date by subtracting the number of days in the bill, minus zero or one day—whichever resulted in a start date of the day after the previous bill's read date

After calculating the start dates according to the method described above, we verified that most bills were seamless with their preceding bill.

Finally, to prepare the final analysis data, Cadmus merged program data with billing data for the treatment and control group customers.

Regression Analysis of Customer Energy Use

Following the *Uniform Methods Project* and State and Local Energy Efficiency Action Network protocols, Cadmus used a difference-in-differences (D-in-D) panel regression of customer monthly energy consumption to estimate the average daily savings per customer in 2017. The regression analysis is expected to yield an unbiased estimate of savings due to the random assignment of customers to treatment and control groups. As a check of the D-in-D savings estimates, Cadmus also estimated the savings using the regression method of Allcott and Rogers (2014).[8]

The panel regression included customer fixed effects, month-by-year fixed effects, and HDDs and CDDs to control for differences in baseload energy use between customers, changes in energy use over time, and demand for space heating and space cooling:

Equation 1

$$ADC_{it} = \alpha_i + \beta_1 PART_{it} * POST2014_{it} + \beta_2 PART_{it} * POST2015_{it} + \beta_3 PART_{it} * POST2016_{it} + \beta_4 PART_{it} * POST2017_{it} + \gamma_1 HDD_{it} + \gamma_2 CDD_{it} + \tau_t + \varepsilon_{it}$$

Where:

ADC_{it}	=	Average daily electricity consumption for customer 'i' in period 't.'
α_i	=	Average energy consumption for customer 'i' not sensitive to time or weather. The model controls for baseload energy use by including customer fixed effects.
β_1	=	Coefficient indicating the average effect of receiving a HER on daily electricity consumption in calendar year 2014. Average daily kilowatt-hour savings per treated customer equal -1 * β_1.
$PART_{it}$	=	An indicator variable for assignment of the customer to the treatment or control group (= 1 for treatment group; = 0 for control group).
$POST2014_{it}$	=	Indicator variable for whether the month was a calendar year 2014 post-treatment month for customer 'i' (= 1 if the month was in 2014 and was the month that the first report was received or a subsequent month; = 0 for all other months).
β_2	=	Coefficient indicating the average effect of receiving a HER on daily electricity consumption in calendar year 2015. Average daily kilowatt-hour savings per treated customer equal -1 * β_2.
$POST2015_{it}$	=	Indicator variable for whether the month was a calendar year 2015 post-treatment month for customer 'i' (= 1 if the month was in 2015 and was the month that the first report was received or a subsequent month; = 0 for all other months).
β_3	=	Coefficient indicating the average effect of receiving a HER on daily electricity consumption in calendar year 2016. Average daily kilowatt-hour savings per treated customer equal -1 * β_3.

[8] Allcott, H., and T. Rogers. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review* 104, no. 10 (2014): 3003–3037.

$POST2016_{it}$	=	Indicator variable for whether the month was a calendar year 2016 post-treatment month for customer 'i' (= 1 if the month was in 2016 and was the month that the first report was received or a subsequent month; = 0 for all other months).
β_4	=	Coefficient indicating the average effect of receiving a HER on daily electricity consumption in calendar year 2017. Average daily kilowatt-hours savings per treated customer equal -1 * β_4.
$POST2017_{it}$	=	Indicator variable for whether the month was a calendar year 2017 post-treatment month for customer 'i' (= 1 if the month was in 2017 and was the month that the first report was received or a subsequent month; = 0 for all other months).
γ_1	=	Coefficient indicating the average effect of a HDD on daily elecricity consumption.
HDD_{it}	=	Monthly HDDs for customer 'i' in period 't.'
γ_2	=	Coefficient indicating the average effect of a CDD on daily elecricity consumption.
CDD_{it}	=	Monthly CDDs for customer 'i' in period 't.'
τ_t	=	Average energy consumption in month 't' reflecting unobservable factors specific to the month. The model controls for these effects by including month-by-year fixed effects.[9]
ε_{it}	=	Error term for customer 'i' in month 't.'

Cadmus estimated the model by ordinary least squares (OLS) and reported standard errors that were adjusted for the correlation of each home's energy use over time (Huber-White standard errors).[10] The

9 POST was not included as a stand-alone variable in the regression, as very little variation occurred between treatment group homes in the month of the first report delivery. If little such variation occurs, the model can be estimated with POST or with month-by-year fixed effects, but not with both.

10 Bertrand, Marianne, Esther Duflo, and Sendil Mullainathan. "How Much Should We Trust Difference-in-Differences Estimates?" *Quarterly Journal of Economics* 119, no. 1 (2004): 249–275.

regression produced an estimate of average daily savings per treated customer for 2014, 2015, 2016, and 2017.[11]

We estimated several versions of Equation 1 to check the robustness of the savings estimates to changes in model specifications. Such specifications tested the effects of including (or excluding) customer fixed effects, month-by-year fixed effects, HDDs, and CDDs.

In addition (as noted above), we estimated the savings using only post-treatment energy use data for treatment and control group customers, following the approach of Allcott and Rogers (2014) and of Burlig, Preonas, and Woerman (2017).[12] This approach included customer pre-treatment energy-use variables as regressors to control for variation between customers' average monthly energy consumption. Cadmus expected that the results would not be sensitive to changes in the model specifications due to the evaluation's RCT design and the large size of the analysis sample. The impact evaluation results (described in the *Evaluation Findings* chapter) shows that the savings estimates proved very robust.

In addition, Cadmus estimated average daily savings per customer for each month of the post-treatment period between November 2014 and December 2017. These estimates revealed how savings evolved over the course of the program's first and second calendar years. The estimates also indicated whether savings varied seasonally.

Finally, we estimated savings for the low, medium, and high energy consumption homes. Opower assigned customers to an energy consumption group based on their energy consumption during the year preceding treatment. This analysis revealed how savings depended on a customer's pre-treatment energy consumption.

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11 A small number of customers (n=936) assigned to the treatment group did not receive HERs. After random assignments to treatment or control groups, Opower determined that some customers did not have valid addresses or did not have sufficient billing histories to generate reports. To preserve the RCT's validity and the treatment and control groups' equivalence, Cadmus left these customers in the impact evaluation analysis sample. (To drop treatment group customers from the analysis sample would have required dropping control customers for whom it would be infeasible to deliver a HERs. Opower did not provide this information to Cadmus.) Consequently, the regression analysis yielded an estimate of the average intent-to-treat (ITT) effect, not the average treatment effect for the treated (ATT). The intent-to-treat effect equaled the average daily savings per customer for customers that Opower intended to send a HERs (that is, the average savings across customers who received a report and customers to whom Opower intended to deliver a report but could not). This differs from the average treatment effect for the treated, which is the average daily savings per customer of customers receiving a report. However, the difference between these two approaches was negligible due to the very small percentage of customers in the treatment group who did not receive a report.

12 See Allcott and Rogers, 2014. The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." American Economic Review, 104 (10): 3003-37. Also, Burlig, F., L. Preonas, and M. Woerman, 2017. "Panel Data and Experimental Design." Energy Institute at Haas working paper. Available online https://ei.haas.berkeley.edu/research/papers/WP%20277.pdf

Estimate Program Savings

Cadmus estimated program savings for November 2014 to December 2014, January 2015 to December 2015 (Wave 1 only), January 2015 to December 2016 (Waves 1 and 2), and January 2017 to December 2017 (Waves 1, 2, and 3) by multiplying the estimate of average daily savings per customer, derived from the regression in Equation 1, by the number of treatment days during that period for customers in the treatment group.

Let i=1, 2, …, N index the number of customers in the treatment group. The RCBS Pilot savings for calendar year 'j' is given by Equation 2.

Equation 2

$$\text{RCBS Pilot Savings} = -\beta_j * \left(\sum_{i=1}^{N} \text{Treatment Days}_i\right)$$

Where:

β_j = Average daily savings per customer for calendar year 'j' from estimation of regression in Equation 1.

Treatment Days_i = Number of days during calendar year 'j' that the customer account remained active after the first report date.

Efficiency Program Uplift Analysis

As HERs provided personalized savings recommendations and promoted EVT's efficiency program offerings, the RCBS Pilot was expected to increase participation in EVT's efficiency programs. Following standard industry terminology, this lift in program participation is known as efficiency program uplift. We estimated the uplift and the resulting savings for EVT's programs in 2017.

Cadmus estimated uplift for downstream energy efficiency programs in each year (November and December 2014, 2015, 2016, and 2017). Downstream efficiency programs provide rebates to customers who install efficiency measures and then apply for rebates.[13] EVT tracks participation in these programs at the customer level. Although this evaluation pertains to 2017, it is necessary to account for participation in previous years because most energy efficiency measures have a multiyear life and continue to save energy.

Cadmus also estimated program uplift for EVT's upstream efficient lighting program using customer survey data. As upstream lighting programs provide rebates to customers at the point of sale, in general, it is not possible to track the LED purchases of specific customers.

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[13] The programs or measure groups included Building Performance, Business New Construction Prescriptive, C&I Retrofit, Customer Equipment Replacement, Efficient Products, Home Performance with ENERGY STAR, Low Income Single Family Retrofit, Low Income Single Family New Construction, Multifamily New Construction, Multifamily Market Rate, Multifamily Retrofit Custom, Multifamily Retrofit, Prescriptive Equipment Replacement, Residential New Construction, Residential Retrofit, Residential Upstream, and Upstream Incentive.

Estimating savings uplift is important for two reasons:

- Uplift is an important effect of energy reports and a potential source of savings.
- Savings from efficiency program uplift is measured in both the regression-based estimate of savings (described above) and in impact evaluations of EVT's other efficiency programs. Therefore, this evaluation must measure and subtract uplift savings from the residential portfolio savings to avoid double-counting.

Uplift and Uplift Savings Definitions

Cadmus measured efficiency program participation uplift as the difference between treatment group customers' and control group customers' rates of program participation, as shown in Equation 3.

Equation 3

$$\text{Participation Uplift} = \Delta\rho = \rho_T - \rho_C$$

Where:

ρ_j = The efficiency program participation rate during treatment for group 'j' (where j=T for treated customers and *C* for control customers), with the participation rate defined as the ratio of efficiency program participants in the treatment [control] group to the number of treatment [control] group customers.

Percent uplift expresses the participation uplift relative to the baseline participation rate for control group homes, shown in Equation 4.

Equation 4

$$\text{Percent Participation Uplift} = \%\Delta\rho = \Delta\rho/\rho_C$$

This equation provides the percentage effect of the RCBS Pilot on participation. For example, if RCBS Pilot participation uplift was 0.2%, then treated customers participated at a rate that was 0.2 percentage points greater than that of control group customers. If the baseline participation rate for the control group was 0.4%, $\%\Delta\rho$ would equal 50%, indicating that the RCBS Pilot increased program participation by 50%.

Cadmus estimated RCBS Pilot savings from participation uplift similarly: by replacing the program participation rate with the average savings per customer from efficiency program participation σ_j, j in {C,T}.

Equation 5

$$\text{Uplift savings per customer} = \sigma_T - \sigma_C$$

Where:

σ_j = Average efficiency program savings per treated (control) customer

Multiplying uplift savings per customer by the number of customers (N_T) assigned to the treatment group homes yielded an estimate of RCBS Pilot savings from participation in EVT's efficiency program (see Equation 6).

Equation 6

$$\text{Program uplift savings} = \Delta\sigma * N_T$$

Estimating Uplift for Downstream Rebate Programs

To estimate the lift in participation and savings provided by HERs, Cadmus linked RCBS Pilot treatment and control group customers to EVT's efficiency program tracking data for November 2014 to December 2017. Each row of the tracking database corresponded to the installation of a specific efficiency measure (such as a heat pump or attic ceiling insulation) at a premise on a specific date. The database contained the premise ID, customer account, location (street address, city, and zip code), EVT program name, measure name, installation date, and deemed annual savings.

To estimate savings uplift, we made several adjustments to the deemed annual savings of measures in the tracking data:

- Prorated savings of non-weather-sensitive measures for the installation date. We assumed that savings were distributed uniformly across days of the calendar year.
- Prorated savings of weather-sensitive measures for the installation date. We assumed that savings were distributed throughout the year in accordance with the distribution of weather-normal HDDs for space heating measures and of weather-normal CDDs for space cooling measures.
- Prorated savings for customers with accounts that became inactive during the calendar year.

Cadmus then aggregated the measure tracking data to the customer, energy efficiency program, and calendar year or the customer and calendar year. Finally, Cadmus calculated the HERs impact on participation and efficiency program savings using the equations described above.

Estimating Uplift for Upstream Rebate Programs

As EVT provided utility customers with rebates for LEDs at the point of sale in 2017, customer-level data on LED purchases were unavailable in EVT's efficiency program tracking database.[14] To collect customer-level information, Cadmus surveyed approximately 800 treatment and control group customers about their purchases and installations of LEDs in the previous 12 months, then used their responses to estimate uplift for upstream lighting measures. Specifically, we estimated the HERs savings from the purchase and installation of LEDs using Equation 7.

Equation 7

Lighting Savings Uplift = TE(Q) * ISR * kWh savings/bulb * Time Installed * % incentivized * Treated Customers

[14] EVT stopped providing incentives for CFLs at the point of sale in 2016.

Where:

TE(Q) = Treatment effect of RCBS Pilot on quantity of LED bulbs purchased or received for free.

ISR = In-service rate, or the percentage of purchased LED bulbs installed in sockets in the home.

kWh savings/bulb = Annual expected savings per LED bulb.

Time Installed = Average length of time (in years) that purchased bulbs were installed in 2017.

% incentivized = Percentage of LED bulbs sold in 2017 to residential customers in Vermont who received a rebate from EVT.

Treated Customers= Average number of treated customers during 2016.

Table 4 shows the data sources for the variables of the lighting uplift savings calculation in Equation 7.

Table 4. Lighting Uplift Data Sources and Estimation Approach

Variable	Data	Estimation Approach
TE(Q)	Survey responses about quantities of LEDs purchased or received for free in previous 12 months	Treatment effect estimated by comparing randomized treatment and control groups using zero-inflated negative binomial regression model.
ISR (In-Service Rate)	Survey responses about number of LEDs purchased or received for free in previous 12 months that customers installed	In-service rate estimated by regressing customer count of installed bulbs on customer quantity purchased and customer quantity purchased interacted with treatment group indicator, with no intercept.
kWh savings/bulb	Vermont Technical Resource Manual for 2017	Annual kilowatt-hour savings per bulb obtained from the Vermont Technical Resource Manual for 2017.
Time Installed (in years)	Cadmus calculation	Bulbs were installed at a constant rate over 2017 so the average installation time for purchased bulb was six months for Waves 1 and 2. Average Time Installed for Wave 3 customers equaled 0.375 months since first reports were delivered at the end of March 2017.
% incentivized	Survey responses about the number of LEDs purchased or received for free in previous 12 months that customers installed, and the number of LEDs EVT rebated in 2017	The ratio of average number of bulbs rebated by EVT per Vermont residential utility customer in 2017 to the average number of bulbs purchased per Vermont residential utility customer was based on RCBS Pilot customer surveys.
Number of treated customers	RCBS Pilot tracking data	Treated customers were estimated as the average number of customers treated during 2017. A customer was treated in a month if they were assigned to the treatment group and their account was active.

Evaluation Findings

This section describes findings from the customer surveys, energy savings analysis, efficiency program uplift analysis, cost effectiveness analysis, and persistence analysis.

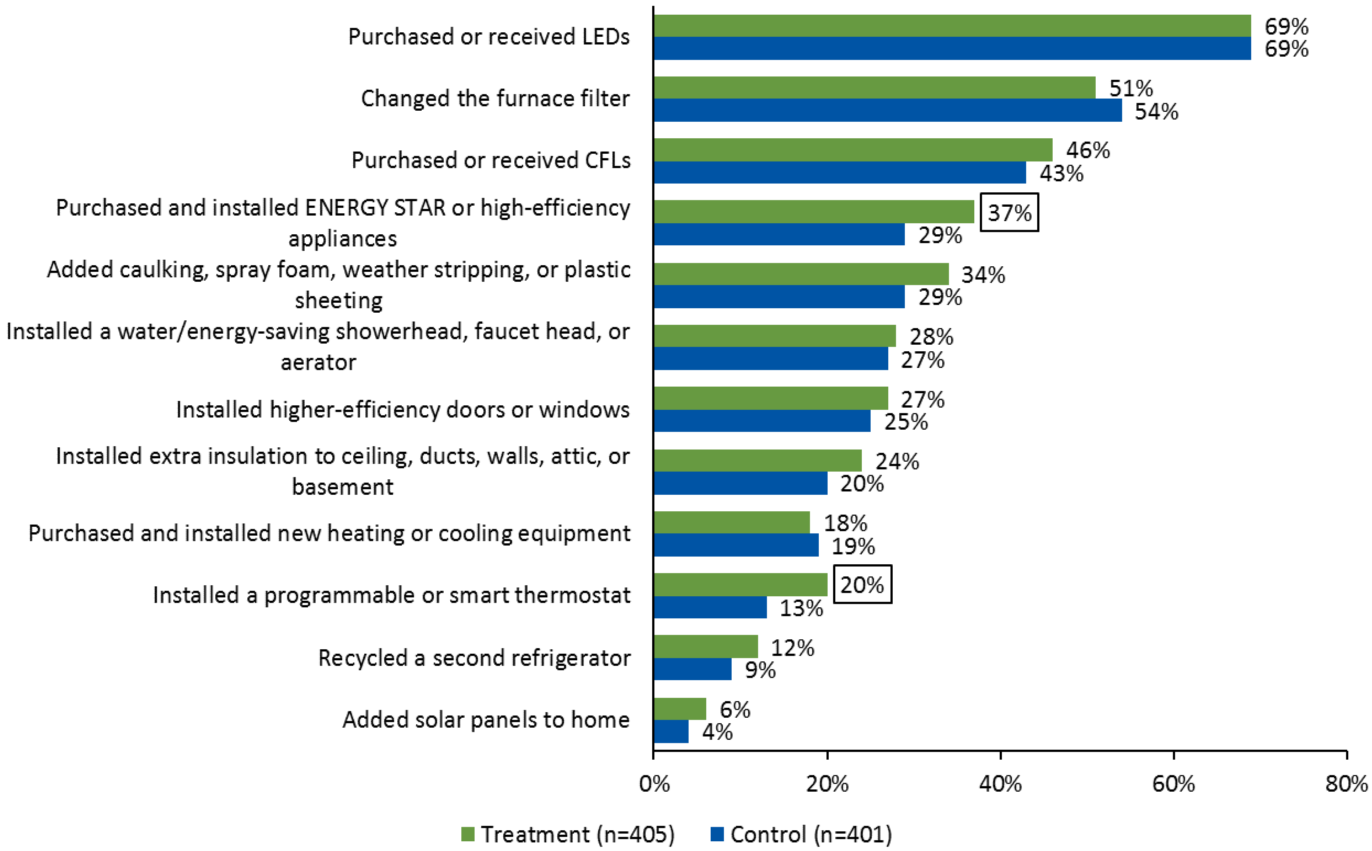
Customer Surveys

The following sections investigate self-reported energy-saving improvements between treatment and control group customers, energy-saving behavior, and satisfaction with HERs. Response comparisons between treatment and control groups indicated some influence of HERs on energy-saving improvements and behaviors. Overall, average satisfaction ratings with HERs have increased despite a decrease in readership and recall of the reports over the past two evaluation years.

Self-Reported Energy-Saving Improvements

The survey asked about whether respondents had made specific energy efficiency improvements including changing a furnace filter, installing extra insulation, or purchasing energy-efficient lighting, ENERGY STAR or high-efficiency appliances, or new heating or cooling equipment. The treatment group reported a statistically significant higher implementation rate than the control group for smart or programmable thermostats and for purchasing high-efficiency appliances (Figure 2). There were not statistically significant differences in implementation rates for the other measures.

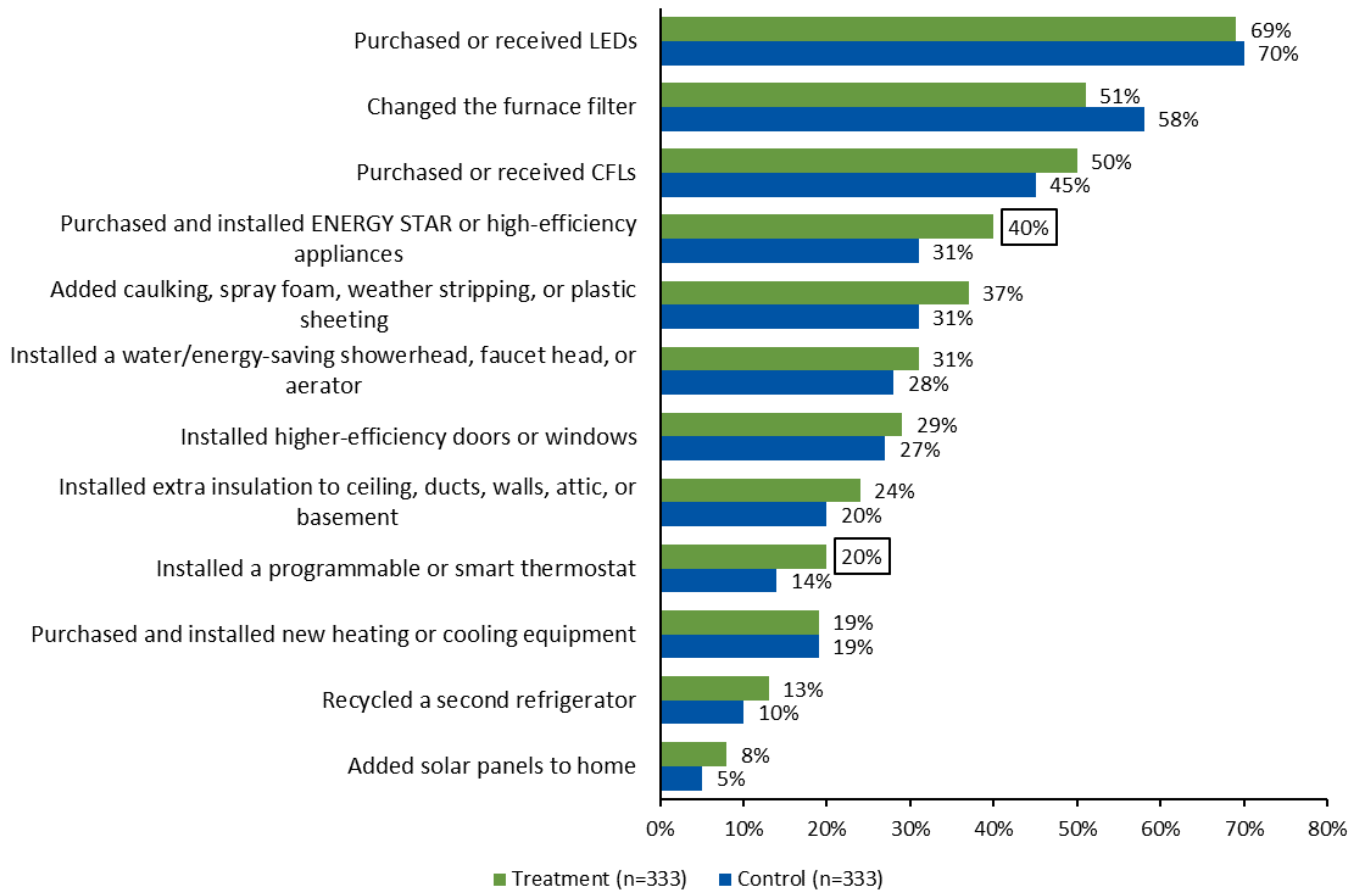
Figure 2. Self-Reported Energy-Saving Improvements



Note: The boxed values denote differences that are statistically significant at the 5% level.

Figure 3 shows measure adoption rates for Wave 1 and Wave 2 customers, who participated in the pilot the longest and received the neighbor comparison treatment. Treated customers reported a statistically significant higher rate than the control group of installing high-efficiency appliances and installing a smart thermostat (Figure 3).

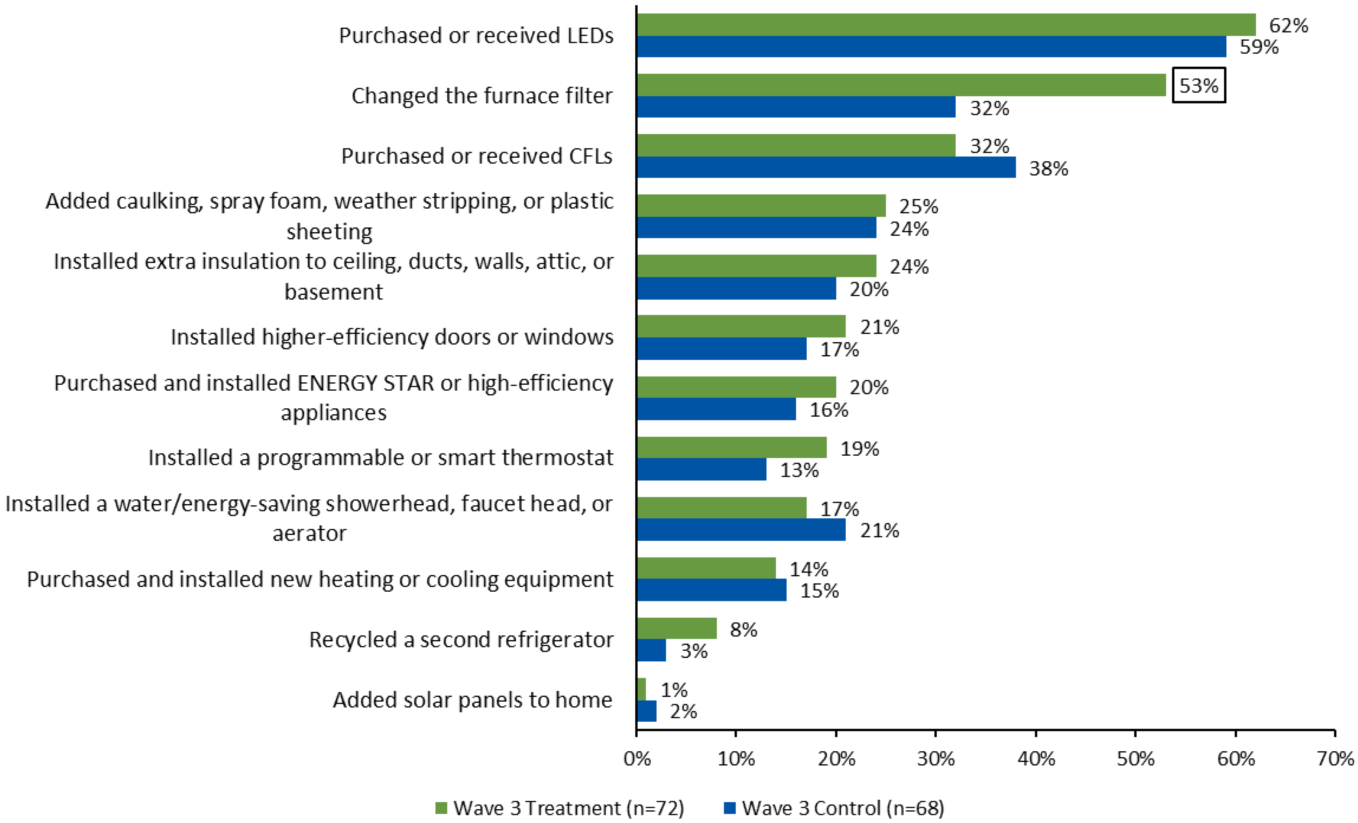
Figure 3. Wave 1 and 2 Self-Reported Energy-Saving Improvements



Note: The boxed values denote differences that are statistically significant at the 5% level. Treatment and control are weighted percentages for Waves 1 and 2.

In Wave 3, treated customers implemented eight measures at a higher rate than control customers (Figure 4). Treatment customers reported implementing many measures at a higher rate than control customers, but the sample sizes are relatively small, and only the difference for changing the furnace filter was statistically significant.

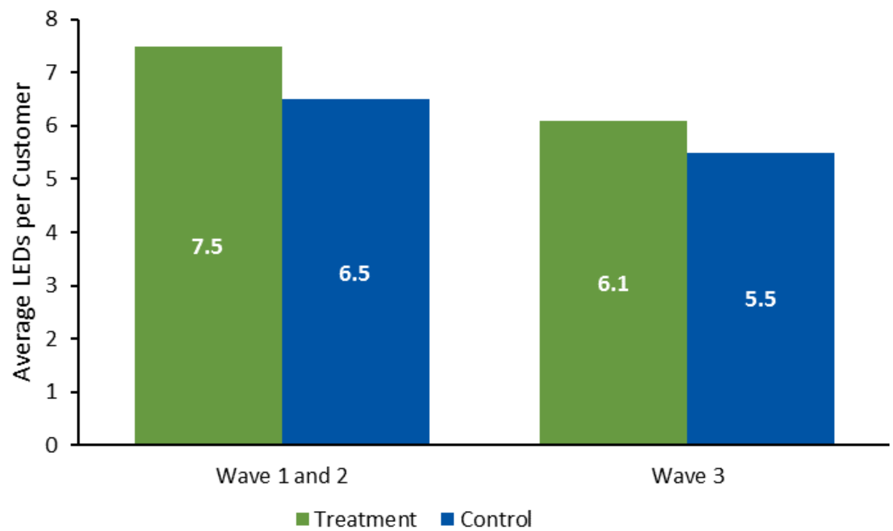
Figure 4. Wave 3 Self-Reported Energy-Saving Improvements



Note: The boxed values denote differences that are statistically significant at the 5% level.
Treatment and control are weighted percentages for Waves 1 and 2.

Cadmus asked respondents about the number of LED bulbs purchased or received for free. As shown in Figure 5, control group customers in Waves 1 and 2 purchased or received an average of 6.5 LEDs per customer (n=279) and treatment group customers purchased or received an average of 7.5 LEDs per customer (n=287). This difference of one LED bulb was not statistically significant at the 10% level, however. In Wave 3, the treatment group purchased or received an average of 6.1 LEDs and control group customers purchased or received an average of 5.5 LEDs per customer. Across all waves, the difference in LEDs between treated and control customers was 0.7 LEDs. None of the differences between the treatment and control groups was statistically significant at conventional levels.

Figure 5. Average Number of LEDs Purchased or Received for Free

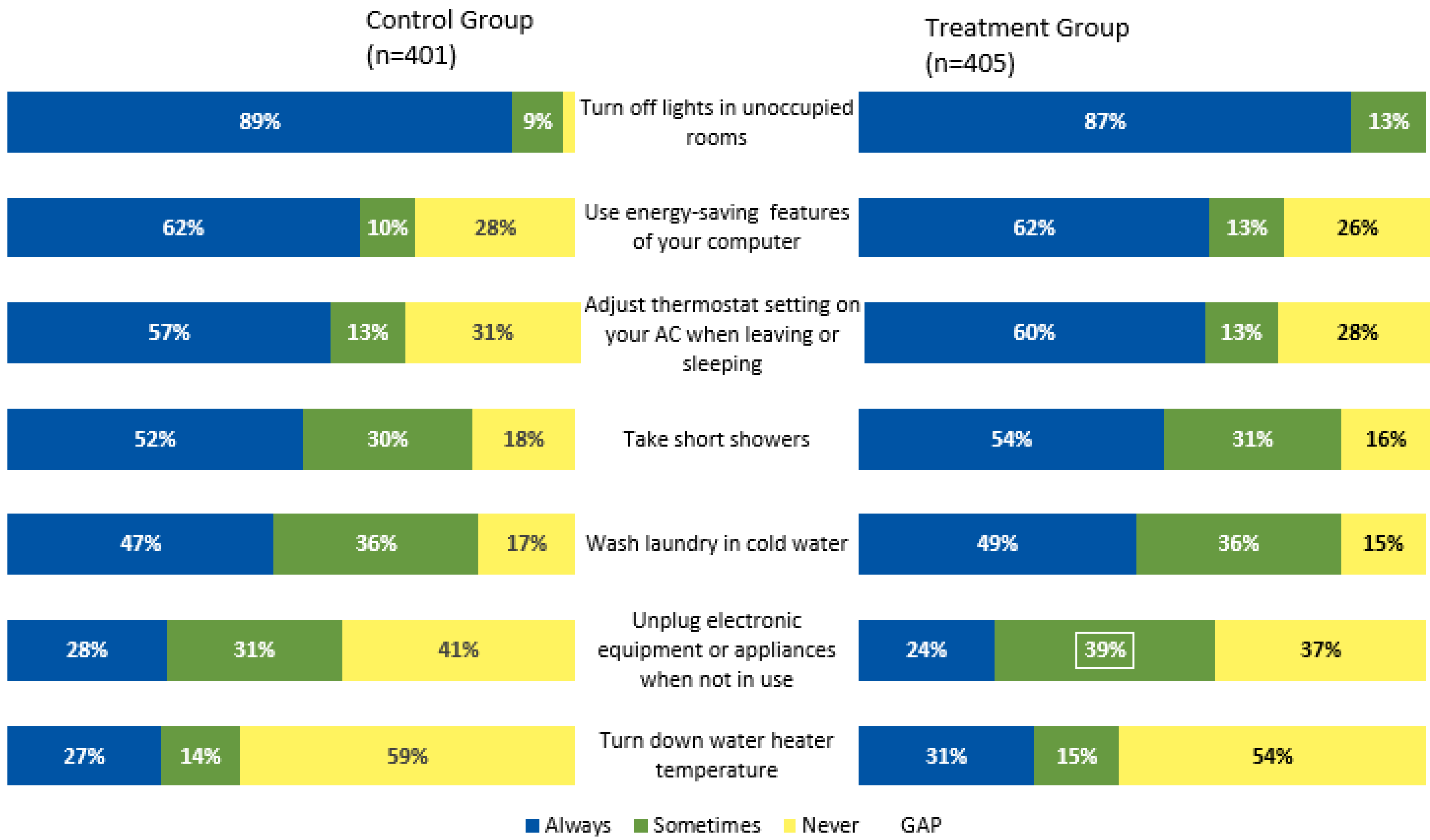


Cadmus also asked treated customers (n=341) about specific energy-saving improvements the HERs prompted them to make. The top response was that the customer did not make any improvements suggested in the reports (43%), followed by installing LEDs or CFLs (39%) and "other" (14%).

Self-Reported Frequency of Energy-Saving Actions

Figure 6 presents the energy-saving actions taken by treatment and control group respondents. There were statistically significant differences (at the 5% level) between treatment and control groups in the likelihood of sometimes unplugging electronic equipment or appliances when not in use. Both groups indicated that they always turn off lights in rooms that are unoccupied (88%) most frequently, followed by always using the energy-saving or sleep features of their computer (62%).

Figure 6. Self-Reported Frequency of Taking Energy-Saving Actions



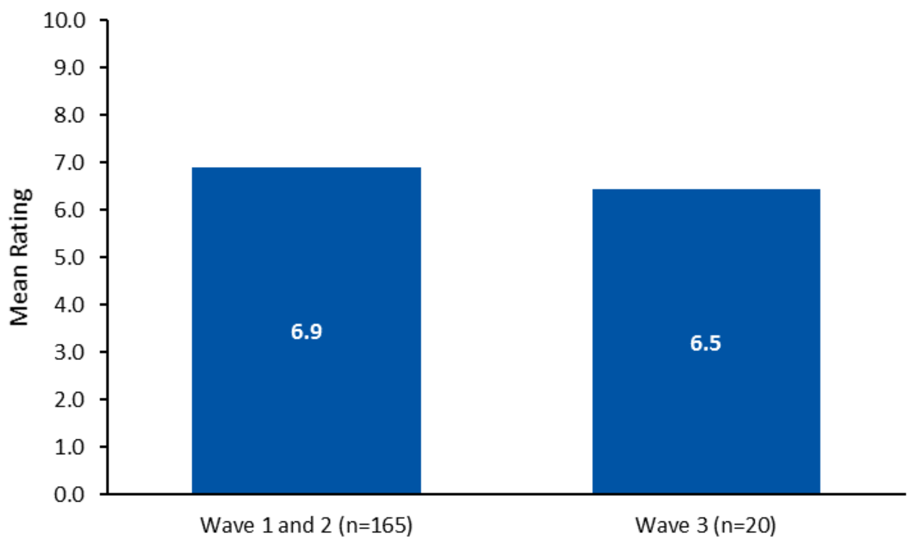
Note: The boxed value denotes a difference that is statistically significant at the 10% level.

Satisfaction with HERs

On average, treatment group respondents were moderately satisfied with the HERs, providing a mean satisfaction rating of 6.9 on a 0 to 10 scale where 0 means *extremely dissatisfied* and 10 means *extremely satisfied* (n=185, Figure 7). Wave 3 customers were slightly less satisfied with the HERs, reporting a mean satisfaction rating of 6.5.

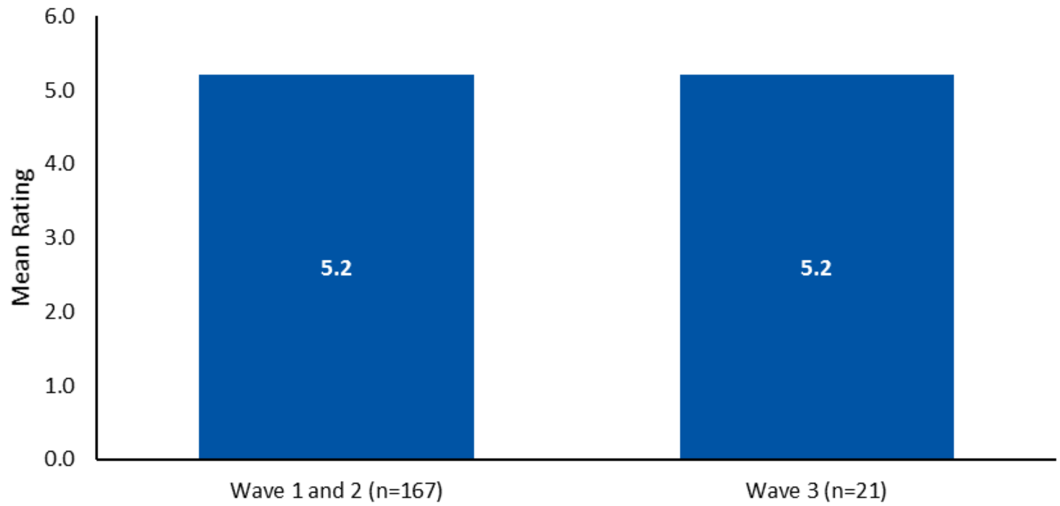
Despite naming and describing the Current Insights report in the survey, the response rate about HER satisfaction was only about 50% due to a low HER recall rate. Of the 405 surveyed treated customers, 203 said that they did not recall or remember seeing one of the HERs. Seventeen customers were unsure how to rate their satisfaction or preferred not to answer.

Figure 7. Satisfaction Rating of Home Energy Reports



The treatment group reported that the HERs were moderately important in their decision to make energy-saving improvements. Across waves, customers reported a mean score of 5.2 (n=188) on a scale of 0 to 10 where 0 means *not at all important* and 10 means *very important* (Figure 8).

Figure 8. Importance of Home Energy Reports in Making Energy-Saving Improvements



Comparison of Survey Results by Year and Between Waves 1, 2 and 3

Table 5 compares the 2016 and 2017 survey results for the treatment groups. One of the three categories showed improvement in 2017 (satisfaction with HERs) and the other two categories declined (recall of HERs and readership of HERs). Satisfaction with HERs increased despite the decrease in readership and recall of the reports. The improvement in satisfaction may be related to the redesigned reports which included removal of the neighbor comparison module.

Table 5. Comparison of 2016 and 2017 Survey Results

Category	2016 Survey	2017 Survey	Trend (Difference)	
Recall of HERs	68%	60%	↓	8%
Fully or Partially Read HERs	67%	62%	↓	5%
Mean HERS satisfaction Rating	5.9	7.0	↑	1.1

Energy-Savings Analysis

Cadmus analyzed customer monthly billing consumption data to estimate the RCBS Pilot savings in 2017. Table 6 shows estimates of average daily savings per customer for the last two months of 2014 and for calendar years 2015 through 2017. We estimated the savings using our preferred D-in-D model specification (Model 1), as well as from five other models (Models 2 through 6) to test the robustness of the estimates to changes in model specification. The additional models excluded different variables included in Model 1. The preferred model specification included customer-fixed effects, month-by-year fixed effects, HDDs, and CDDs.

There are several factors to consider in assessing the program savings:

- Wave 1 customers received their first report in November 2014. The 2014 savings for Wave 1 only pertain to November and December of that year.
- Wave 2 customers received their first report in February 2016. The 2016 savings for Wave 2 only pertain to February through December of that year.
- Wave 3 customers received their first report in March 2017. The 2017 savings for Wave 3 customers only pertain to March through December of that year.
- EVT suspended delivery of HERs for five months beginning in March 2015 and resumed delivery in August 2015.
- EVT removed the neighbor comparison from all reports in 2017. Wave 3 customers never received reports with neighbor comparisons.

Table 6. Customer Consumption Regression Analysis Results

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6 (Post-Only)
Wave 1						
Average Daily Savings per Customer (kWh), 11/2014 and 12/2014	0.053	0.044	0.045	0.052	0.056	0.026
	(0.049)	(0.104)	(0.050)	(0.050)	(0.049)	(0.046)
Average Daily Savings per Customer (kWh), 2015	0.161[a]	0.140	0.161[a]	0.164[a]	0.163[a]	0.158[a]
	(0.036)	(0.087)	(0.036)	(0.036)	(0.036)	(0.034)
Average Daily Savings per Customer (kWh), 2016	0.316[a]	0.290[a]	0.320[a]	0.322[a]	0.318[a]	0.334[a]
	(0.047)	(0.092)	(0.048)	(0.048)	(0.047)	(0.046)
Average Daily Savings per Customer (kWh), 2017	0.291[a]	0.264[a]	0.286[a]	0.287[a]	0.292[a]	0.298[a]
	(0.055)	(0.097)	(0.055)	(0.055)	(0.055)	(0.054)
Customer Fixed Effects	Yes	No	Yes	Yes	Yes	No
Weather Variables	Yes	No	No	Yes	No	Yes
Month-Year Fixed Effects	Yes	No	No	No	Yes	Yes
Model R-Squared	0.101	0.0007	0.0029	0.958	0.092	0.913
Number of Customers	124,662	124,662	124,662	124,662	124,662	119,584
Number of Observations	5,598,299	5,598,299	5,598,299	5,598,299	5,598,299	4,030,494
Wave 2						
Average Daily Savings per Customer (kWh), 2/2016 through 12/2016	0.109	0.034	0.129	0.126	0.099	0.121
	(0.101)	(0.259)	(0.105)	(0.105)	(0.102)	(0.103)
Average Daily Savings per Customer (kWh), 2017	0.130	0.140	0.173	0.147	0.127	0.127
	(0.157)	(0.318)	(0.161)	(0.161)	(0.157)	(0.166)
Customer Fixed Effects	Yes	No	Yes	Yes	Yes	No
Weather Variables	Yes	No	No	Yes	No	Yes
Month-Year Fixed Effects	Yes	No	No	No	Yes	Yes
Model R-Squared	0.091	0.000	0.000	0.086	0.081	0.916
Number of Customers	14,600	14,600	14,600	14,600	14,600	14,232
Number of Observations	412,889	412,889	412,889	412,889	412,889	263,653

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6 (Post-Only)
Wave 3						
Average Daily Savings per Customer (kWh), 3/2017 through 12/2017	0.008	0.022	-0.008	-0.072	0.019	0.050
	(0.054)	(0.206)	(0.059)	(0.058)	(0.054)	(0.057)
Customer Fixed Effects	Yes	No	Yes	Yes	Yes	No
Weather Variables	Yes	No	No	Yes	No	Yes
Month-Year Fixed Effects	Yes	No	No	No	Yes	Yes
Model R-Squared	0.071	0.000	0.000	0.066	0.061	0.915
Number of Customers	19,821	19,821	19,821	19,821	19,821	19,429
Number of Observations	406,428	406,428	406,428	406,428	406,428	166,829

Notes: The dependent variable is customer average daily electricity consumption for a month-year during the analysis period. Cadmus estimated models by OLS, separately for each wave. Standard errors in parentheses were clustered on customers. We estimated all models with pre-treatment and post-treatment monthly consumption data except Model 6, which uses only post-treatment data (but includes pre-treatment consumption as an independent variable).

[a] Denotes statistical significance at the 1% level.

According to the preferred Model 1, in 2017, daily savings per customer averaged 0.29 kWh for Wave 1 customers, 0.13 kWh for Wave 2 customers, and 0.01 kWh for Wave 3 customers. However, these savings estimates were only statistically significant for Wave 1. For perspective, the estimated savings for Wave 1 could have been achieved by turning off a 75-watt incandescent lamp for about four hours per day or by replacing one 60-watt incandescent lamp, used for approximately six hours each day, with one 8-watt LED.

The estimated daily savings for Wave 1 customers during 2017 is slightly less than but not statistically different from the estimated savings for 2016.[15] Thus, although EVT removed the neighbor comparison from the reports, there has not been a statistically significant drop in savings. This suggests that HER savings persist after the neighbor comparison treatment was terminated or that other portions of the report are effective at maintaining savings.

The estimated daily savings for Wave 2 customers during 2017 is slightly greater than the point estimate for 2016. Average daily savings per Wave 2 customer increased from 0.11 kWh in 2016 to 0.13 kWh in 2017, an increase of 15%. However, the estimates are imprecisely estimated, so it is difficult to draw any conclusions about the savings trend.

Wave 3 customers did not save electricity in 2017. The point estimate was 0.01 kWh, and the 90% confidence interval for savings was [-0.07, 0.09]; based on this confidence interval, we can reject with 90% likelihood the hypothesis that average daily savings for Wave 3 customers were greater than 0.1 kWh. As noted above, Wave 3 customers never received neighbor comparisons, which could explain

[15] Savings for Wave 1 customers in 2014, 2015, and 2016 were consistent with Cadmus' prior reported estimates. In the 2016 annual report, the estimated savings for 2016 were 0.275 kWh per day per customer. There is a slight difference because this analysis estimated the model parameters using a longer data series that included bills between January 2017 and December 2017.

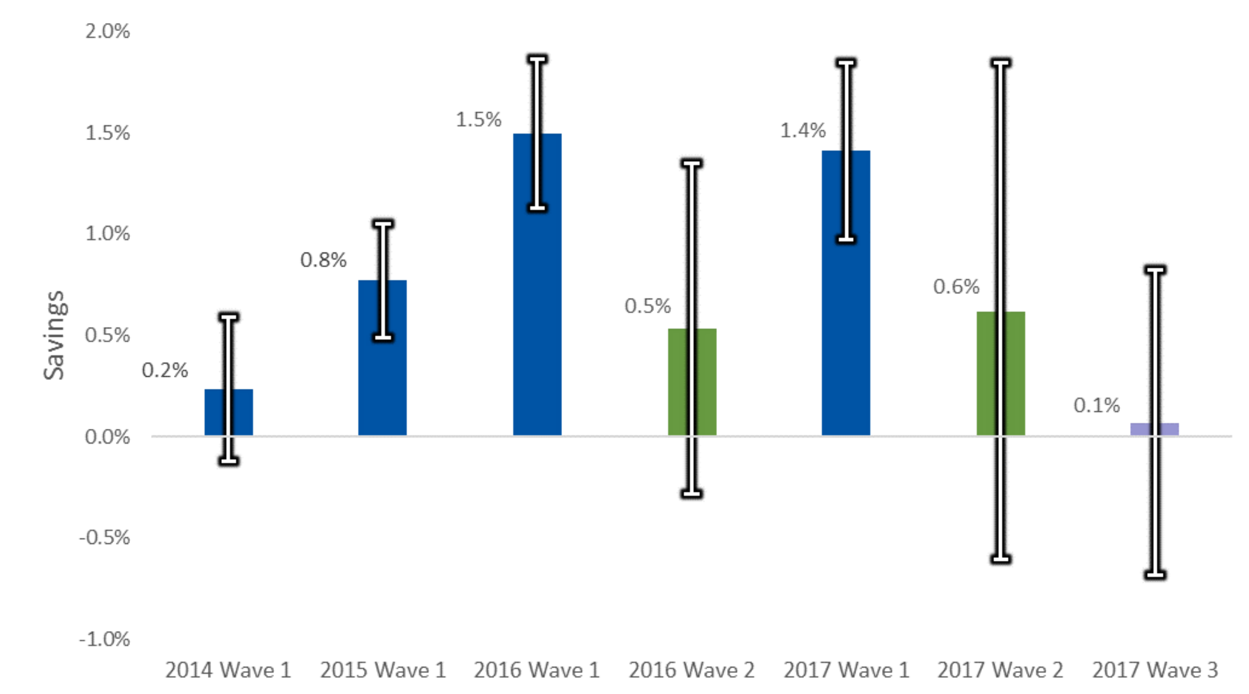
their low estimated savings and their lower first-year savings compared to Wave 1 and Wave 2 customers, who did receive the comparisons. Other potential explanations for the lack of Wave 3 savings include that Wave 3 customers were more likely than Wave 1 and Wave 2 customers to reside in multi-family buildings, which may have had lower savings potential than single-family dwellings. Also, about 30 percent of customers assigned to the Wave 2 or Wave 3 treatment or control groups occupied homes previously assigned to the treatment group or control group of a previous wave. This included 2,288 Wave 2 or Wave 3 control group customers who occupied homes that had previously received treatment and 5,473 Wave 2 or Wave 3 treatment group customers who occupied homes that had been previously treated. As behavior-based treatments such as HERs cause customers to make lasting energy efficiency improvements, savings will persist after customers move out of their homes, limiting the potential for savings from treating new customers and reducing program cost-effectiveness.

Models 2 through Model 5 tested the robustness of Model 1 by alternately removing customer fixed effects, weather variables, and month-year fixed effects. Cadmus estimated alternative model specifications for all three waves, and the estimates remained highly robust to changes in model specification. Adding or removing variables from the model did not affect the point estimates significantly. Cadmus' Wave 1 savings estimate for 2017 were significant across all models—an expected result, as estimates of treatment effects in large randomized field experiments typically prove robust to changes in model specifications. Cadmus' 2017 savings estimate for Wave 2 was not significant in any of the models, which may be due to the small size of the Wave 2 control group (n=2,406). Cadmus' 2017 savings estimate for Wave 3 was not significant in any of the models.

Model 6 employs the post-only approach of Allcott and Rogers (2014) and yielded savings estimates similar to those of Model 1.

Figure 4 shows the average daily savings per customer by wave and year as a percentage of average daily consumption of control group customers.

Figure 4. Annual Savings by Wave



Notes: Cadmus estimated the percentage savings as average daily savings per customer from Model 1 to average daily consumption of control group customers. The error bars show 90% confidence intervals for savings estimates.

In 2017, treated customers in Wave 1 saved 1.4% of consumption, just below the percentage savings in 2016. Leveling-off of energy savings, as exhibited by Wave 1, is typical for mature HER programs (Khawaja and Stewart 2014).[16] After the second or third year of treatment, HER savings usually reach a steady state and are maintained while treatment continues.

As a percentage of consumption, the RCBS Pilot savings are lower than those of other programs, which typically range between 1.5% and 2.5%. As noted in Cadmus' 2015 evaluation report,[17] differences between Vermont and the rest of the United States in climate and residential utility customer primary electric end uses may explain the lower behavior-based savings in Vermont. Most Vermont customers do not heat their homes with electricity, instead relying on heating oil, natural gas, propane, wood, or a

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[16] Khawaja, M. Sami and James Stewart, 2014. Long Run Savings and Cost-Effectiveness of Home Energy Reports Programs. Cadmus white paper. Available at: http://www.cadmusgroup.com/wp-content/uploads/2014/11/Cadmus_Home_Energy_Reports_Winter2014.pdf

[17] Cadmus. *Evaluation of Residential Customer Behavioral Savings Pilot*. 2016. Prepared for Vermont Public Service Department. http://publicservice.vermont.gov/sites/dps/files/VT%202015%20HER%20Behavior%20Pilot%20Evaluation%20Report.pdf

combination.[18] Also, Vermont's relatively cool summers and the low penetration of central air conditioning in Vermont homes also likely resulted in smaller air conditioning loads and less potential for savings.[19]

Cadmus' analysis of pre-program consumption during the random assignment of homes indicated that most homes in the sample already used much less electricity than homes in most other areas of the country. Across all fuels and sectors, Vermont's total energy consumption per capita in 2013 was the fifth lowest in the United States.[20] The RCBS Pilot's savings potential was also less than that for most other utility HER programs since it included a significant number of low- and medium-use customers. Many HER programs focus on high-use customers, who offer the greatest savings potential.

As was shown above in Figure 4, Wave 2 customers saved 0.6% of consumption during 2017. This result is less than half the savings estimate of 1.5% for Wave 1 customers' second full year (2016). Again, Wave 2 savings are not precisely estimated because of the small size of the control group.

Figure 5, Figure 6, and Figure 7 show the percentage savings by month and year since treatment began for Wave 1, Wave 2, and Wave 3 customers, respectively. Wave 1 savings followed an upward trend through 2016 before decreasing after March 2017. This decay could reflect changes to the HERs in 2017 that involved removing the neighbor comparison. However, without having conducted a randomized experiment of the effect of removing the neighbor comparison, it is not possible to know with certainty.

Wave 1 savings from 2014 to 2017 appear to vary seasonally, peaking in the spring and fall. No seasonality is evident for Wave 2 and Wave 3 customers.

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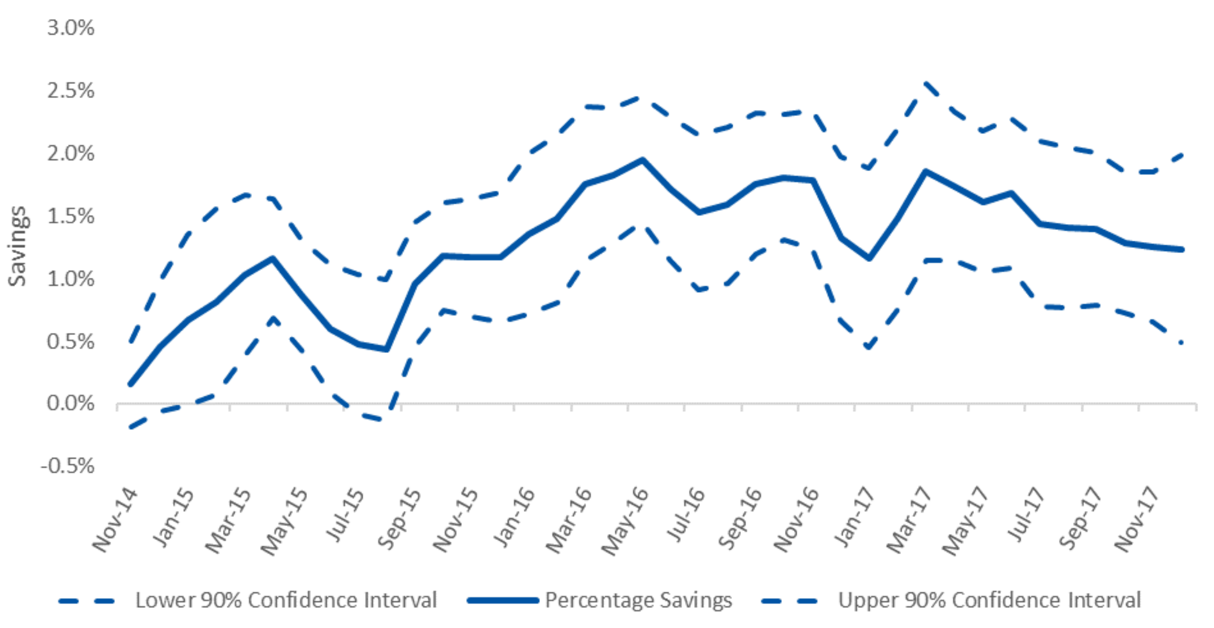
18 NMR Group, Inc. *Vermont Single-Family Existing Homes Onsite Report.* February 15, 2013. Available online: http://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/EVT_Performance_Eval/VT%20SF%20Existing%20Homes%20Onsite%20Report%20-%20final%20021513.pdf

19 Among NMR Group's on-site inspection group, just 17% of homes had a window air conditioning unit, and only 2% had a central air conditioning system.

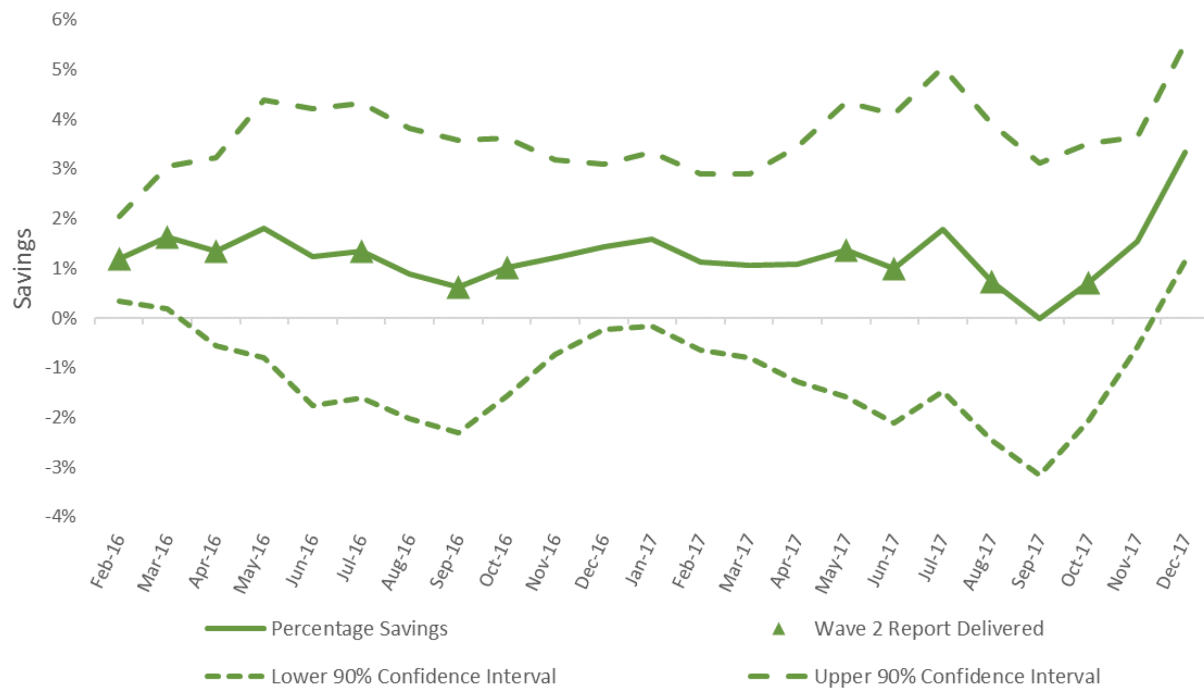
20 U.S. Energy Information Administration. "Rankings: Total Energy per Capita (Consumed), 2013 (million Btu)." Available online: http://www.eia.gov/state/rankings/?sid=VT#series/12

Figure 5. Wave 1 Customer Savings by Month and Year



Notes: Savings estimates in Figure 5, Figure 6, and Figure 7 were based on D-in-D regression analysis of customer monthly energy use on month-year fixed effects, HDD and CDD weather variables, customer fixed effects, and month-year fixed effects interacted with treatment indicator variable. Cadmus estimated the confidence intervals using standard errors clustered on customers. Report delivery dates are shown in the figures for Wave 2 and Wave 3 customers; for Wave 1 customers' report delivery dates, the report delivery dates depended on the usage group and are not shown.

Figure 6. Wave 2 Customer Savings by Month and Year



Notes: See previous figure.

Figure 7. Wave 3 Customer Savings by Month and Year

Notes: See previous figure.

Regression Results for Wave 1 Energy-Use Groups

To investigate possible heterogeneity of HER savings between customers in 2017, Cadmus estimated HER savings for the low-, medium-, and high-use customers in Wave 1.[21] To estimate savings by usage group, Cadmus separately estimated the preferred model specification (Model 1 described above) for each of the three Wave 1 usage groups. Table 7 shows the results of this analysis.

Table 7. Regression Results for Wave 1 Energy-Use Groups

	High	Medium	Low
Average Daily Savings per Wave 1 Customer (kWh), 11/2014 and 12/2014	0.097 (0.147)	0.000 (0.086)	0.059 (0.047)
Average Daily Savings per Wave 1 Customer (kWh), 2015	0.380[a] (0.103)	0.111[b] (0.066)	0.070[c] (0.034)
Average Daily Savings per Wave 1 Customer (kWh), 2016	0.579[a] (0.134)	0.357[a] (0.085)	0.150[a] (0.044)
Average Daily Savings per Wave 1 Customer (kWh), 2017	0.563[a] (0.156)	0.349[a] (0.095)	0.111[c] (0.051)
Model R-Squared	0.161	0.121	0.090
Number of Homes	31,314	31,335	62,013
Number of Monthly Observations	1,439,006	1,423,006	2,735,543

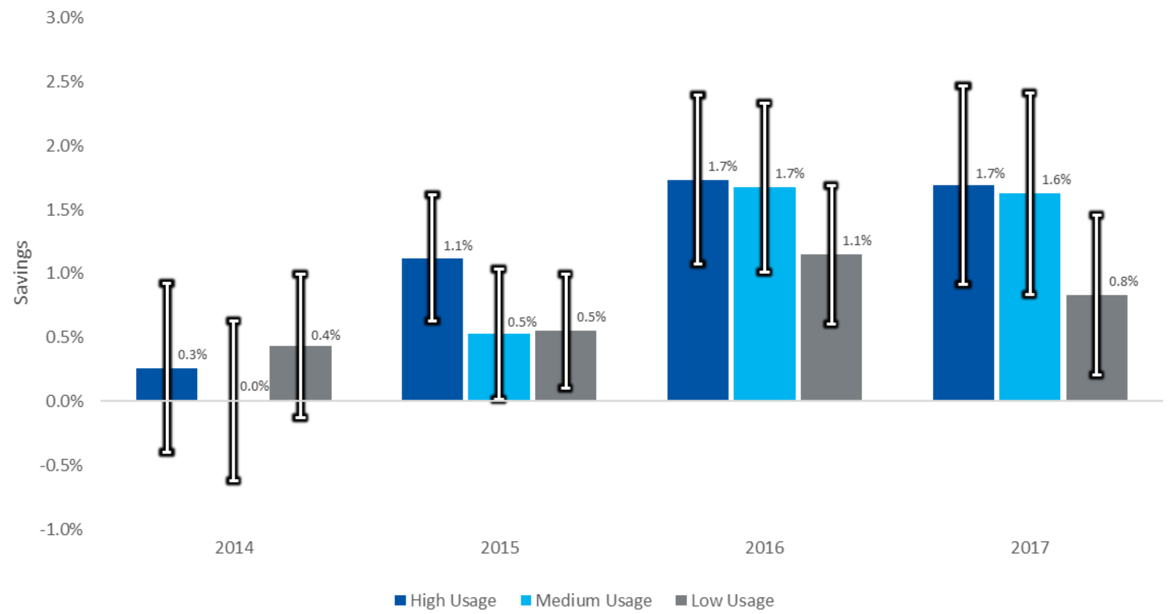
Notes: The dependent variable is the customer's average daily electricity consumption for a month and year during the analysis period. All models include customer fixed effects, month-by-year fixed effects, and HDD and CDD weather variables. Cadmus estimated the models by OLS and clustered standard errors (shown in parentheses) on customers.
[a] Denotes statistical significance at the 1% level.
[b] Denotes statistical significance at the 10% level.
[c] Denotes statistical significance at the 5% level.

As expected, there was a strong relationship between pre-treatment energy consumption and HER savings. High-use customers saved the most electricity, with an average daily savings of 0.563 kWh during 2017. This result was statistically significant at the 1% level and approximately equal to this group's 2016 savings. The low-use group saved the least, at an average of 0.111 kWh per customer per day (statistically significant at the 5% level). The medium-use group saved an average of 0.349 kWh per day, statistically significant at the 1% level and approximately equal to the 2016 savings. The differences in 2017 savings between high-use and low-use customers and between medium-use and low-use are statistically significant at the 5% level.

Figure 8 shows the savings for each usage group as a percentage of the consumption of control group customers in the corresponding usage group during the program period.

[21] The program did not stratify Wave 2 or Wave 3 customers within usage groups, so Cadmus did not perform this analysis for these waves.

Figure 8. Annual Savings by Energy-Use Group (Wave 1 Customers)

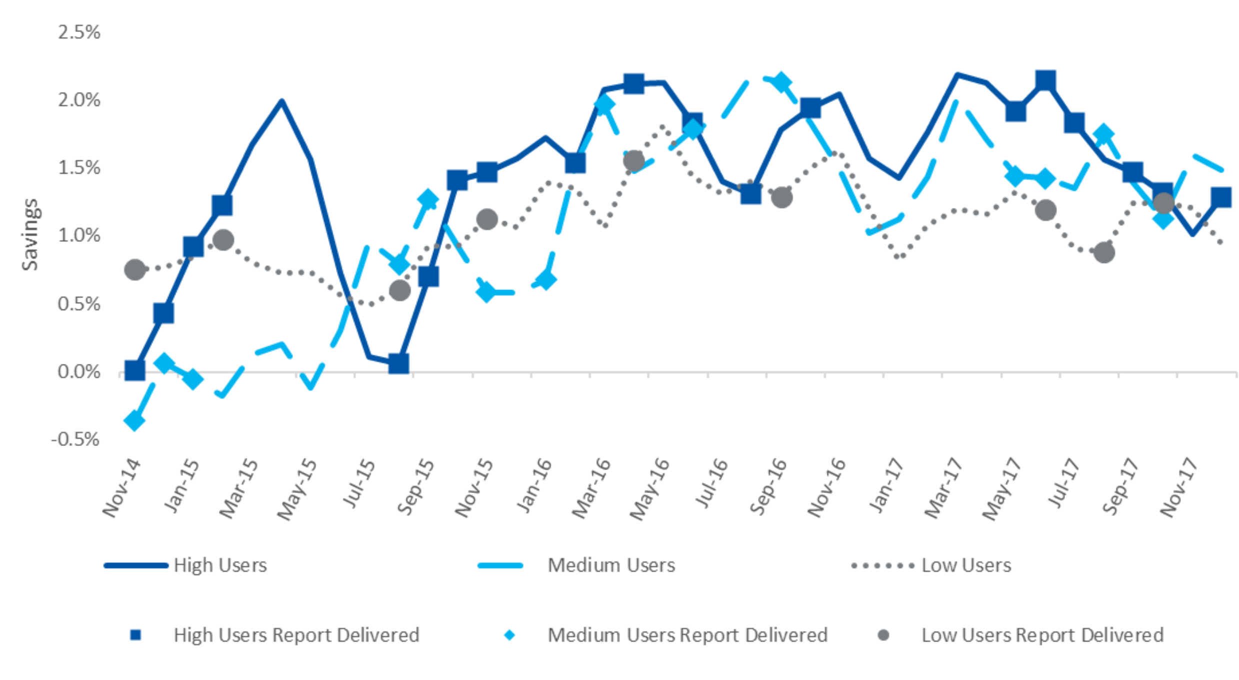


Note: Savings estimates were based on D-in-D regression analysis of customer monthly energy consumption on month-year fixed effects, HDD and CDD weather variables, customer fixed effects, and month-year fixed effects. Error bars show 90% confidence intervals estimated with clustered standard errors.

Although there were clear and consistent differences in kWh savings between usage groups, the differences in percentage savings were less strong. High-use customers had the largest percentage savings in each year except 2014, but the difference between high-use and medium-use customers was small in 2016 and 2017; in these two years, high-use customers save 1.7%, medium-use customers saved 1.6%, and low-use customers saved 0.8% in 2017 and 1.1% in 2016.

Figure 9 shows point estimates of program savings by month and year for each Wave 1 energy-use group. The markers indicate the months when customers received HERs.

Figure 9. Wave 1 Savings by Month and Usage Group



In 2015, 2016, and the first half of 2017, high users exhibited seasonal savings trends, with savings peaking during the winter and shoulder months. This result is consistent with many high users employing electricity for space heating or having large lighting loads. After March 2017, a downward trend in high-user is evident, which may be related to the removal of the peer comparisons from the reports. Savings also appear to be seasonal for medium users, but their highest savings tended to occur during summer months. This suggests that medium users may use electricity for air conditioning. Medium users also achieved the highest monthly percentage of savings observed for any group and month in the program, at 2.5% during August 2016. Together, the high-use and medium-use customers accounted for most of the Wave 1 savings seasonality shown in Figure 9.

Savings Estimates by Income Status

Cadmus estimated the average daily savings per customer by income status in 2017. Using third-party data on household income and size, Opower developed and provided Cadmus with a low-income flag for Wave 1 customers. (Cadmus did not estimate savings for Wave 2 or Wave 3 customers because the sample sizes for these groups were too small to yield statistically significant impact estimates.)

Table 8 shows customer counts, the average daily consumption per customer, and the distribution of customers across usage groups for low- and regular-income customers.

Table 8. Customer Characteristics by Income Status

Criteria	Low Income	Regular Income
Average Daily Consumption per Customer (kWh)	19.3	21.3
Low Electricity User (%)	56	46
Medium Electricity User (%)	23	26
High Electricity User (%)	21	28
Number of Customers in Analysis Sample	47,697	76,965

Notes: Cadmus estimated the average daily consumption per Wave 1 control group customer between November 2014 and December 2017. Opower determined low-income customer status according to household income and size and EVT's definition of a low-income household.

Thirty-eight percent of customers qualified as low income: these customers had slightly lower daily average consumption (at 20 kWh versus 22 kWh) and a higher percentage of them were in the low energy-use group.

Table 9 shows estimates of the average incremental daily savings per low-income customer in 2014, 2015, 2016, and 2017. A positive coefficient indicates that low-income customers saved more energy than regular-income customers and a negative coefficient indicates that low-income customers saved less energy.

Table 9. Regression Estimates of Incremental Savings for Wave 1 Low-Income Customers

Criteria	Estimates
Incremental Average Daily Savings per Wave 1 Low-Income Customer (kWh), November 2014-December 2014	-0.148 (0.099)
Incremental Average Daily Savings per Wave 1 Low-Income Customer (kWh), January 2015–December 2015	0.039 (0.075)
Incremental Average Daily Savings per Wave 1 Low-Income Customer (kWh), January 2016–December 2016	-0.015 (0.098)
Incremental Average Daily Savings per Wave 1 Low-Income Customer (kWh), January 2017–December 2017	-0.009 (0.113)
Model R-Squared	0.103
Number of Monthly Energy Use Observations	5,598,299

Notes: The dependent variable was customer average daily electricity consumption in a month and year between November 2013 and December 2017. The model included customer fixed effects, month-by-year fixed effects, month-by-year fixed effects interacted with low-income indicator variable, and HDD and CDD weather variables. Cadmus estimated the model by OLS and clustered standard errors (in parentheses) on customers.

[a] Denotes statistical significance at the 1% level.

[b] Denotes statistical significance at the 5% level.

[c] Denotes statistical significance at the 10% level.

None of the estimates of incremental savings for low-income customers was statistically different from zero. This suggests that, on average, low-income and regular-income customers saved at the same rate.[22]

Program Savings Estimates

Table 10 shows annual RCBS Pilot savings from 2014 to 2017 for each wave and for the pilot overall. Cadmus estimated these savings by multiplying the estimate of average daily savings per home from Model 1 of Table 6 by the total number of treatment days for treated homes in each wave.[23]

Table 10. Total 2017 Residential Customer Behavioral Savings Pilot Savings by Wave

Wave	Average Daily Savings per Customer (kWh)	Number of Customer Treated Days	Total Program Savings (MWh)	90% Confidence Interval	
				Lower Bound	Upper Bound
Wave 1	0.291	30,707,568	8,933	6,175	11,691
Wave 2	0.130	3,267,520	425	-417	1,268
Wave 3	0.008	2,669,676	22	-213	257
Total		**36,644,764**	**9,380**	**6,486**	**12,274**

Notes: Cadmus used estimates of average daily savings per customers in 2017 from Model 1 of Table 6.

As shown in Table 10, during 2017, the RCBS Pilot saved 9,380 MWh, with an estimated 90% confidence interval for the savings of [6,486 MWh, 12,274 MWh]. Wave 1 customers accounted for 95% of the 2017 savings.

Table 11 shows total savings achieved by each energy usage group in 2017. As we estimated use-group savings using separate regression analyses, the sum of the use-group savings does not equal the estimated program savings shown in Table 10.

Table 11. Total 2017 Wave 1 Program Savings by Energy-Use Group

Usage Group	Average Daily Savings per Customer (kWh)	Number of Customer Treated Days	Total Program Savings (MWh)	90% Confidence Interval (MWh)	
				Lower Bound	Upper Bound
High	0.563	8,031,098	4,518	2,459	6,578
Medium	0.349	7,881,901	2,750	1,516	3,984
Low	0.111	14,794,569	1,641	397	2,884

Cadmus estimated that in 2017, customers in the high-use group saved 4,518 MWh, customers in the medium-use group saved 2,750 MWh, and customers in the low-use group saved 1,641 MWh. Although

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22 The large percentage of customers who counted as low-income suggests that the low-income category was broadly defined. A narrower definition focused on the poorest customers might reveal differences in savings.

23 Cadmus defined the number of program days per customer as the number of days between the date that Opower generated the customer's first print report and either the end of the calendar year (December 31) or the home's inactive date, whichever came first. A few treatment group customers' accounts remained active after their wave's first report month but lacked a first print report date. In such cases, Cadmus assigned that customer the average first report date of all other customers with available data.

low-use customers accounted for approximately 50% of treatment days, they only accounted for 18% of savings.

Table 12 shows the evaluated annual RCBS Pilot savings between 2014 and 2017 for each wave. The savings estimates for 2014-2016 are from previous evaluations. The pilot savings were approximately 2% less in 2017 than 2016.

Table 12. Annual Residential Customer Behavioral Savings Pilot Savings, 2014 through 2017

Wave	Annual Savings (MWh)				
	2014	2015	2016	2017	Total
Wave 1	304	5,621	9,093	8,933	23,951
Wave 2	N/A	N/A	435	425	860
Wave 3	N/A	N/A	N/A	22	22
Total	**304**	**5,621**	**9,528**	**9,380**	**24,833**

Note: Source for 2014-2016 savings estimates were previous Cadmus evaluations of the RCBS pilot. Estimate for 2017 from Table 10.

Comparison of Opower Reported Savings and Evaluation Savings Estimates

Table 13 shows a comparison of Opower's forecast of annual savings, Opower's reported savings, and Cadmus' evaluated savings for 2017. Opower forecasted savings of 9,645 MWh for 2017 and reported savings of 8,412 MWh in 2017. Cadmus estimated savings of 9,380 MWh, or 110% of Opower's reported savings for 2017. Cadmus estimated higher savings for Wave 1 and lower savings for Wave 2 than Opower. Though Opower's reported savings were less than the evaluated savings (by 968 MWh), the 90% confidence intervals for the evaluated savings contained Opower's estimate.

Table 13. Comparison of Cadmus and Opower 2017 Savings Estimates

Wave	Opower Forecasted Savings[a]		Opower Reported Savings[a]		Cadmus Evaluated Savings		Opower Estimate within Evaluation 90% Confidence Interval?
	MWh	% Savings	MWh	% Savings	MWh	% Savings	
Wave 1	8,439	1.38%	8,102	1.08%	8,933	1.41%	Yes
Wave 2	738	1.19%	275	0.32%	425	0.62%	Yes
Wave 3	468	0.82%	35	-0.08%	22	0.07%	Yes
Total	**9,645**	**1.32%**	**8,412**	**0.92%**	**9,380**	**1.24%**	**Yes**

[a] Source: EVT - Monthly Savings Results - December 2017.xlsx. EVT provided this workbook to Cadmus, after receiving it from Opower.

Efficiency Program Uplift Analysis

Table 14 shows the estimated lift in energy efficiency program participation and savings for EVT's downstream rebate programs in 2017:

- The first column (Baseline Participation Rate) shows the participation rates of customers in the Wave 1, Wave 2, and Wave 3 control groups.
- The second column (Participation Uplift) shows the HERs' effect on participation rates, measured as the difference in the participation rate between treatment and control group customers.
- The third column (Percentage Participation Uplift) expresses the participation uplift relative to the baseline participation rate.

A participant was a customer who received a rebate from EVT for one or more downstream measures during 2017.

Table 14. Efficiency Vermont Downstream Energy Efficiency Program Participation Uplift for 2017

Wave	Baseline Participation Rate (per 1,000 Customers)[a]	Participation Uplift (Treatment Effect on Participation Rate)	Percentage Participation Uplift
Wave 1	69.0	3.2	4.6%
Wave 2	67.9	2.5	3.7%
Wave 3	36.8	4.6	12.5%
Total	**59.3**	**3.3**	**5.5%**

Notes: Cadmus based these results on analysis of EVT energy efficiency program tracking data and RCBS Pilot participation data. Analysis for Wave 1 and Wave 2 customers covered January 2017 to December 2017, while analysis for Wave 3 customers covered March 2017 to December 2017.

[a] The baseline participation rate was the participation rate of control group customers.

In Wave 1, treated customers participated in EVT downstream energy efficiency programs at higher rate than control group customers. The baseline rate for energy efficiency program participation was 69 per 1,000 customers. HERs increased the participation rate by 3.2 per 1,000 customers, or about 5%.

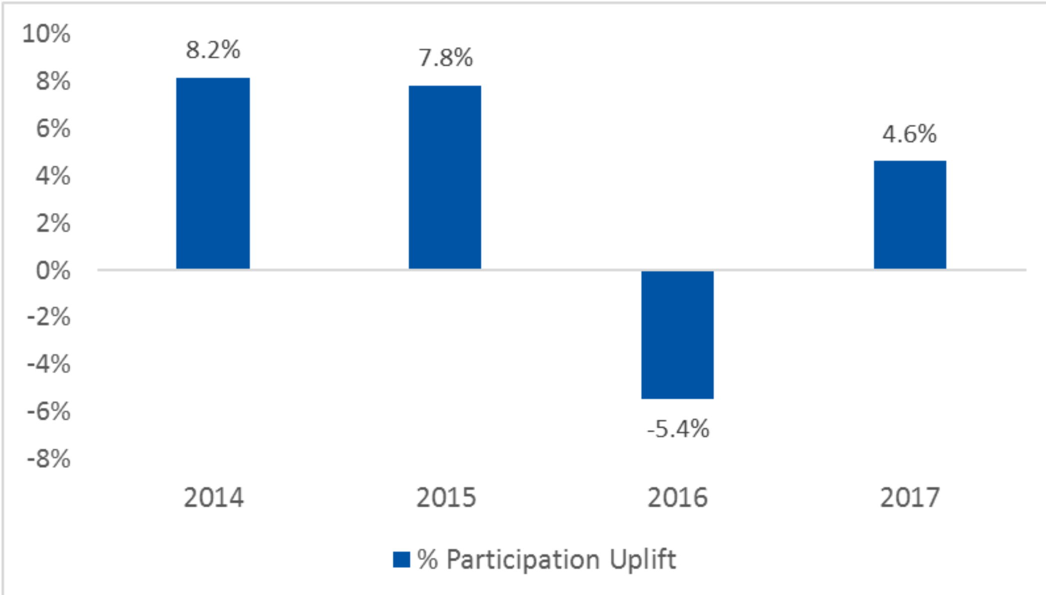
In Wave 2, treated customers also participated at a higher rate than control group customers. The baseline participation rate was 68 per 1,000 customers and HERs increased participation by about 2.5 per 1,000 customers, or 4%. Overall, the effects of HERs on energy efficiency program participation for customers in Wave 1 and Wave 2 were similar.

Although Wave 3 customers did not receive HERs until March 2017, and HERs in 2017 did not include social normative neighbor comparisons, HERs increased participation in EVT downstream energy efficiency programs. The baseline rate of participation for Wave 3 was 37 per 1,000 customers, which was about 50% of the participation rate for Wave 1 and Wave 2. HERs increased participation by 4.6 per 1,000 customers, or 13%. Thus, although HERs led to increased Wave 3 program participation, the lift was not large enough to produce statistically significant electricity savings estimates.

Across all waves, HERs increased participation in EVT downstream energy efficiency programs by 3.3 per 1,000 customers, or 5.5%.

Figure 10 presents participation uplift estimates by program year for Wave 1 customers.

Figure 10. Annual Energy Efficiency Program Participation Uplift for Wave 1



In 2014 and 2015, HERs raised program participation rates by about 8%. However, in 2016, treated customers participated at about a 5% lower rate than control group customers. This could indicate a process of "catch-up," by which HERs accelerated the adoption of efficiency measures—that is, that treatment caused adoption to occur before it would have without treatment. After a treated customer adopted a long-lived high-efficiency measure (such as a refrigerator or air conditioning unit), the customer is not expected to adopt again for the life of the measure. This acceleration could have caused the program participation rate to be higher than normal in the first two years of the RCBS Pilot and lower than normal during later years, where "normal" is measured using the control group participation rate. However, in 2017, HERs increased participation in EVT programs, which casts doubt on the catch-up hypothesis, since it is expected that catch-up would occur over many years.

Table 15 shows estimates of RCBS Pilot energy savings in 2017 from participation in EVT's downstream efficiency programs in 2017 and previous years. The 2017 uplift savings include savings from measures installed in previous years because measures have a multi-year life and continue to produce savings in years after installation. For example, for Wave 1, HERs produced about 118 MWh of savings in 2017 by having increased participation in EVT programs in 2015. The right column shows uplift savings from downstream rebate programs that must be subtracted from residential portfolio savings or RCBS Pilot savings to avoid double-counting.

Table 15. Downstream Energy Efficiency Program Savings Uplift in 2017

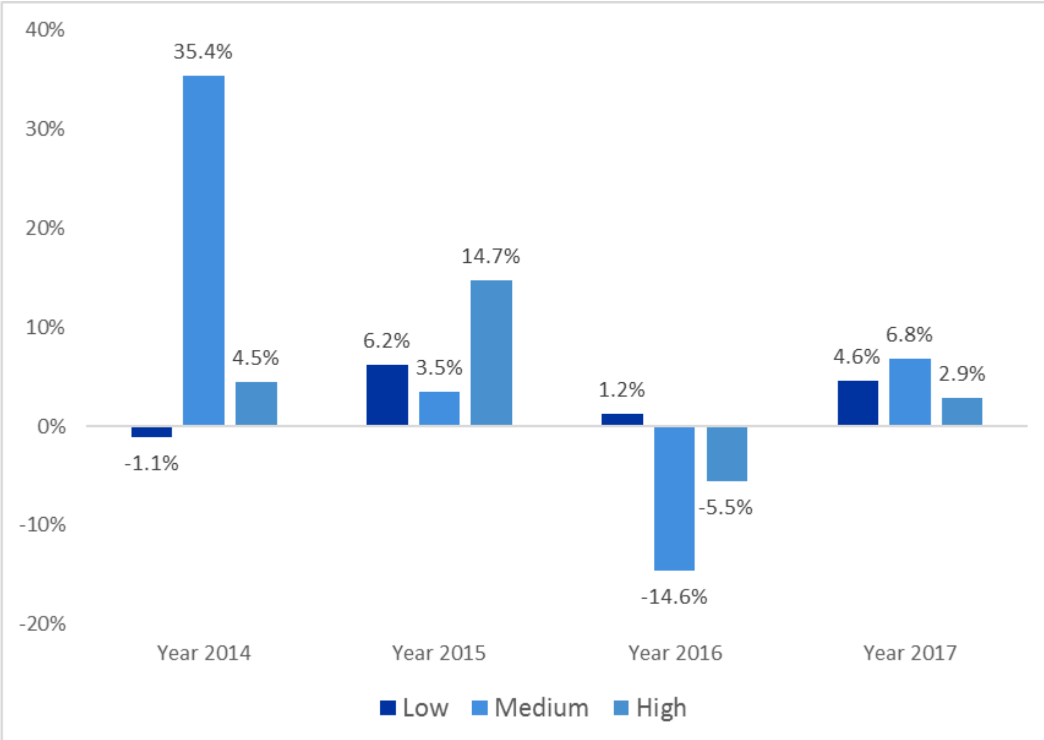
Wave	2017 Uplift Savings (MWh)				Total 2017 Uplift Savings (MWh)
	From 2014 Measures	From 2015 Measures	From 2016 Measures	From 2017 Measures	
Wave 1	-20.6	117.8	506.8	66.6	670.6
Wave 2	N/A	N/A	-47.4	317.4	270.0
Wave 3	N/A	N/A	N/A	34.2	34.2
Total	**-20.6**	**117.8**	**459.4**	**418.2**	**974.8**

Notes: Cadmus based the results on analysis of EVT energy efficiency program tracking data and on RCBS Pilot participation data. Cadmus prorated the annualized deemed savings to account for midyear measure installations, the distribution of weather-sensitive measure savings during the calendar year, and closures of customer accounts.

Overall, HERs produced 974.8 MWh of savings from participation in downstream programs in 2017. These savings constituted about 10% of 2017 RCBS Pilot savings. Wave 1 customers provided the largest lift, accounting for about 671 MWh, or 69% of the downstream program uplift savings. In Wave 1, although treated customers participated at a lower rate than control customers in 2016, treated customers saved more energy per customer, lifting the HER energy savings. Downstream program participation in 2016 from HERs contributed about 507 MWh of uplift electricity savings in 2017.

Figure 11 shows participation uplift by energy-use group for Wave 1 from 2014 to 2017. In 2017, HERs increased the energy efficiency program participation of customers in each group. Treated low-, medium-, and high-consumption customers were about 5%, 7%, and 3% more likely to participate than control customers. In contrast, participation uplift was negative for medium- and high-consumption customers in 2016.

Figure 11. Energy Efficiency Program Participation Uplift by Energy-Use Group



Note: Cadmus based the results on analysis of EVT downstream energy efficiency program tracking data and on RCBS Pilot participation data.

Table 16 shows participation uplift estimates for EVT programs, with the highest overall participation rates being among Wave 1 customers. HERs increased participation in Efficient Products by three per 1,000 treated customers, or 12%, and increased participation in Home Performance with ENERGY STAR by 0.7 per 1,000 customers, or 43%. Treatment group customers had lower participation rates for Low Income Single Family Retrofit and Residential Retrofit, but the baseline rate of participation was relatively low for these programs.

Table 16. Wave 1 Participation Uplift in 2017 for Efficiency Vermont Energy Efficiency Programs

Program	Baseline Participation Rate (per 1,000 Customers)	Participation Uplift (Treatment Effect on Participation Rate per 1,000 Customers)	Percentage Participation Uplift
Efficient Products	24.8	3.0	12.0%
Home Performance with ENERGY STAR	1.6	0.7	42.9%
Low Income Single Family Retrofit	3.8	-0.2	-5.2%
Residential Retrofit	2.1	-0.4	-18.3%
Residential Upstream	16.0	0.7	4.3%

Note: Cadmus based the results on analysis of EVT energy efficiency program tracking data and on RCBS Pilot participation data for 2017.

Table 17 presents participation uplift estimates for Wave 2 customers in 2017. HERs increased participation in Efficient Products by 12.4%, increased participation in Home Performance with ENERGY

STAR by 23%, and increased participation in Residential Retrofit by 39%. Treated customers participated in Low Income Single Family Retrofit and Residential Upstream at a lower rate than control customers.

Table 17. Wave 2 Participation Uplift in 2017 for Efficiency Vermont Energy Efficiency Programs

Program	Baseline Participation Rate (per 1,000 Customers)	Participation Uplift (Treatment Effect on Participation Rate per 1,000 Customers)	Percentage Participation Uplift
Efficient Products	20.7	2.6	12.4%
Home Performance with ENERGY STAR	2.6	0.6	22.8%
Low Income Single Family Retrofit	4.7	-0.5	-9.8%
Residential Retrofit	1.0	0.4	38.6%
Residential Upstream	22.3	-4.5	-20.3%

Note: Cadmus based the results on analysis of EVT energy efficiency program tracking data and on RCBS Pilot participation data for 2017.

Table 18 presents the participation uplift estimates for Wave 3 customers in 2017. HERs increased participation in the Efficient Products and Low Income Single Family Retrofit programs by 26% and 39%, respectively.

Table 18. Wave 3 Participation Uplift in 2017 for Efficiency Vermont Energy Efficiency Programs

Program	Baseline Participation Rate (per 1,000 Customers)	Participation Uplift (Treatment Effect on Participation Rate per 1,000 Customers)	Percentage Participation Uplift
Efficient Products	11.0	2.9	26.0%
Home Performance with ENERGY STAR	2.0	-0.3	-13.0%
Low Income Single Family Retrofit	2.1	0.8	39.1%
Residential Retrofit	1.2	-0.7	-58.3%
Residential Upstream	9.2	0.2	2.0%

Note: Cadmus based the results on analysis of EVT energy efficiency program tracking data and on RCBS Pilot participation data for 2017.

Upstream Rebate Programs

Cadmus also estimated uplift and savings uplift for EVT's upstream lighting program, through which EVT provides rebates at the point of sale to customers who purchase LEDs.[24] Unlike for downstream measures, there was no EVT database of LED rebates that could be linked to individual treatment and control group customers. Consequently, Cadmus surveyed treatment and control group customers about their LED purchases in 2017 and used survey responses to estimate HERs' impacts on efficient lighting purchases. We estimated the average impact per customer of HERs on LED bulb purchases for Wave 1, Wave 2, and Wave 3 customers to maximize the statistical power of the analysis.

24 Cadmus did not include CFLs in the uplift analysis because EVT stopped providing incentives for CFLs through its upstream lighting program in July 2016.

As was described in the *Customer Surveys* section, Cadmus asked survey respondents about the quantity of their LED purchases (or those received for free) and the quantity of LEDs installed during the previous 12 months. When we administered the survey, Wave 1 customers had participated in the RCBS Pilot for about 43 months and Wave 2 customers had participated for about 27 months. As Cadmus was concerned about survey response bias and the representativeness of customers responding to the survey, we verified that respondents were representative of the program population.[25] Although surveyed customers' energy consumption was representative of the program population, it was not possible to rule out that surveyed customers differed regarding other unobserved characteristics that affected their LED purchases.

Table 19 shows the average number of LEDs per customer that treatment and control group respondents reported purchasing in the previous 12 months. Treatment group customers reported purchasing an average of 7.3 LEDs per customer and control group customers reported purchasing an average of 6.5 LEDs per customer. Cadmus estimated the program treatment effects using a zero-inflated negative binomial count regression that accounted for the non-normal distribution of bulb purchases and for the approximately one-third of respondents who reported making no LED purchases.[26] The estimated HER treatment effect from the binomial count regressions was 0.7 LEDs per treated customer. The regression estimate was marginally statistically significant at the 10% level (p value=0.1096). The estimate was robust to the omission or inclusion of different explanatory variables.

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25 Using monthly pre-treatment consumption data for all customers we surveyed or attempted to survey, Cadmus regressed monthly consumption on an indicator variable for assignment to a treatment group, an indicator variable for assignment to a control group, an interaction variable between the treatment group indicator and an indicator variable that the customer completed the survey, and an interaction variable between the control group indicator and the completed survey indicator. The coefficients on the interaction variables were small and statistically significant, indicating that statistically significant differences did not occur between surveyed customers and those Cadmus attempted to survey.

26 Cadmus modeled the probability of a customer purchasing zero bulbs as a function of customer average daily consumption during the pre-treatment period. Neither receiving treatment nor the customer's wave affected this probability. Cadmus modeled the number of LED bulbs purchased conditional on purchasing an LED as a function of customer average daily consumption during the pre-treatment period, wave, and treatment.

Table 19. Home Energy Reports Treatment Effect on LED Purchases

Wave	Bulb Type	Surveyed Customers	Sample Average Number of LEDs Purchased per Customer		Estimated Treatment Effect	p-value from Significance Test
			Treatment Group	Control Group		
Waves 1, 2, and 3	LED	693	7.3	6.5	0.68	0.1096

Note: Cadmus analyzed customer survey responses to questions about LED purchases during the previous 12 months. We excluded customers from the analysis who could not or refused to report the number of LEDs purchased or received for free. Cadmus obtained the treatment effect from the maximum likelihood estimation of a zero-inflated negative binomial count regression of the customer self-reported number of purchased bulbs or bulbs received for free in the previous 12 months on a HER treatment indicator variable.

Table 20 presents the calculation of lift in upstream program savings resulting from HERs. Cadmus estimated the uplift savings by multiplying the HER treatment effect on bulb purchases by the annual kilowatt-hour savings per bulb, then adjusted the resulting savings for the in-service rate, the average time installed, and the percentage of purchased bulbs for which customers received rebates.

Table 20. LED Uplift Savings in 2017

Wave	Treatment Effect (Bulbs Purchased)	Unit Energy Savings (kWh/yr)	In-Service Rate	Average Time Installed (Years)	Bulbs Sold Receiving Rebates	Treated Customers	Uplift Lighting Savings (kWh)	
							Per Treated Customer	Overall
Waves 1, 2, and 3	0.68	34.8	0.801%	0.49	55.2%	104,212	5.1	531,535

Notes: See Table 19 for the data Cadmus used to estimate treatment effects. Cadmus obtained unit energy savings per year for omni-directional LEDs from the 2017 Vermont Technical Resource Manual. We obtained the in-service rate from our OLS regression of the survey of self-reported number of bulbs installed on number of bulbs purchased, with regression intercept set to zero. The average time installed—the length of time that bulbs purchased in 2017 were installed in sockets—assumes that bulbs were purchased and installed at a uniform rate over the year. The percentage of bulbs sold receiving rebates is an estimate of the percentage of bulbs sold in Vermont that EVT rebated. Cadmus obtained this estimate as the ratio of average number of bulbs rebated by EVT per Vermont residential utility customer in 2017 to the average number of bulbs customers reported purchasing based on RCBS Pilot customer surveys. Treated customers equals the average number of treated customers between January and December 2017. Uplift savings are RCBS Pilot savings from the adoption of LEDs.

Cadmus estimated that average annual savings per treated customer from LEDs were 5.3 kWh/year. In 2017, the estimated uplift savings from LEDs purchased in 2017 was 532 MWh. As noted, however, the treatment effect was marginally statistically significant at the 10% level.

Summary of Energy Efficiency Program Uplift Savings

Table 21 summarizes RCBS Pilot uplift savings for EVT downstream and upstream rebate programs in 2017. Total uplift savings for treated Wave 1 customers were 1,100 MWh. Approximately 60% of these savings could be attributed to participation in EVT's downstream efficiency program. Total uplift savings were 316 MWh for treated Wave 2 customers and 91 MWh for Wave 3 customers.

Table 21. Energy Efficiency Program Uplift Savings Summary for 2017

Wave	Downstream Rebate Programs Savings (MWh)	Upstream Lighting Program Savings (MWh)	Total Savings (MWh)
Wave 1	671	429	1,100
Wave 2	270	46	316
Wave 3	34	56	91
Total	**975**	**532**	**1,506**

HERs provided a total lift in savings from EVT program participation of 1,506 MWh, or 16% of the estimated RCBS Pilot savings in 2017. As these savings are counted by EVT's other programs, EVT should subtract them from its portfolio of residential program savings in 2017.[27]

Cost-Effectiveness Analysis

Cadmus estimated the RCBS Pilot's cost-effectiveness for 2017 and overall for 2014 through 2017. This section describes the methodology and results of the cost-effectiveness calculation.

Methodology

Cadmus conducted the cost-effectiveness analysis using the Vermont 2017 Statewide Screening Tool, provided by EVT.[28] EVT uses the SCT to screen Vermont's energy efficiency programs. Table 22 presents the benefits and costs included in the SCT for the RCBS Pilot.

Table 22. Societal Cost Test Benefits and Costs

Benefits	Costs
Electric Energy	Program Administration
Electric Capacity	
DRIPE[a]	
Electric Externalities	
Non-Energy Benefits	

[a] Demand Reduction Induced Price Effects, or DRIPE, is a measure of impacts from reduced electricity consumption due to energy efficiency investments on regional energy and capacity market clearing prices.

Cadmus obtained the energy-savings estimate for 2014, 2015, 2016, and 2017 from analyzing customer monthly electricity bills. Further, we obtained peak demand reduction estimates from our analysis of customer AMI data for the 2016 evaluation.[29] EVT provided the RCBS Pilot administrative costs. As the

27 Cadmus did not apply a gross-to-net factor to the downstream or upstream uplift savings.

28 Cadmus used the 2016 data included in the tool and used 2016 DRIPE values for 2014 and 2015.

29 Cadmus did not perform a HER peak energy-savings analysis using AMI data. We used the 2016 estimate of average energy-savings estimate per customer during ISO New England peak hours to calculate the RCBS Pilot peak demand reduction in 2017. Since the 2016 and 2017 estimates of average daily energy savings per customer were similar, this approach seemed reasonable.

Vermont 2017 Statewide Screening Tool did not include a whole-house load profile reflecting the programs savings, we calculated a whole-house load profile using hourly load data from the U.S. Department of Energy.[30]

Summary of Findings

Table 23 shows RCBS Pilot inputs for the cost-effectiveness calculation. In 2017, administrative program costs amounted to $1,032,070, with total energy savings of 24,833 MWh. The combined 2014 through 2017 analysis includes program administrative implementation costs of $3,375,020 and savings of 24,833 MWh.[31]

Table 23. Vermont 2017 Statewide Screening Tool Inputs

Parameter	2014 and 2015	2016	2017	2014–2017
Savings (kWh)	5,925,000	9,528,000	9,380,000	24,833,000
Savings (kW)	1,570	3,019	2,814	7,403
Program Costs	$1,182,905	$1,160,045	$1,032,070	$3,375,020
EUL (Years)	1			
Load Profile				
Winter Peak	39%			
Winter Off	50%			
Summer Peak	5%			
Summer Off	6%			

Table 25 shows the cost-effectiveness results for the RCBS Pilot.[32] The pilot tracking data indicate that approximately 38% of treated customers were low income according to the EVT definition (see Table 24).

Table 24. Vermont 2015 Low Income Criteria

Number in Household	Income Less than or Equal to
1	$38,900
2	$44,500
3	$50,050
4	$55,600
5	$60,050
6	$64,500
7	$68,950
8	$73,400

30 Cadmus derived the baseload model for a residential home in Burlington using the following source: http://en.openei.org/doe-opendata/dataset/eadfbd10-67a2-4f64-a394-3176c7b686c1/resource/cd6704ba-3f53-4632-8d08-c9597842fde3/download/buildingcharacteristicsforresidentialhourlyloaddata.pdf

31 As the Vermont 2017 Statewide Screening Tool did not include data for 2014, and 2014 savings only occurred in December 2014, Cadmus modeled additional costs and benefits as having occurred starting in 2015.

32 The Vermont 2017 Statewide Screening Tool discounts program costs by 10% for risks and values costs accrued mid-year; hence, the costs in Table 23 and Table 25 do not match.

Therefore, for the methodology applied in the cost-effectiveness analysis, Cadmus assumed that 62% of annual program costs and estimated savings (energy and capacity) applied to the *Standard* market rate and the remaining 38% of savings and costs applied to the *Low Income* market rate.

Cadmus combined the 2014 through 2017 total portfolio results and expressed this in 2017 dollars, as shown in Table 25. The Vermont 2017 Statewide Screening Tool calculates an approximately 15% higher present value of measure benefits for customers on the *Low Income* market rate compared to customers on the *Standard* market rate.

In addition to the upward trend of annual savings achieved, the RCBS Pilot was increasingly more cost-effective each year due to the greater benefits attributed to low-income customers. The 2014 through 2017 results in the table indicate that the pilot was cost-effective, with a benefit/cost ratio of 1.37 and net societal benefits of $1,173,575. The levelized average cost of energy savings was $0.13/kWh. In 2017, the pilot was cost-effective, with a benefit/cost ratio of 1.62. The levelized average cost of saved energy was $0.10/kWh.

Table 25. Residential Customer Behavioral Savings Societal Cost Test Cost-Effectiveness Results[a]

Parameter	2014 and 2015	2016	2017	2014–2017
Benefits including DRIPE Impacts	$1,241,923	$1,587,875	$1,524,109	$4,353,907
Costs	$1,146,266	$1,091,373	$942,693	$3,180,332
Net Benefits	$95,657	$496,502	$581,416	$1,173,575
$/kWh	$0.19	$0.11	$0.10	$0.13
Benefit/Cost Ratio	1.08	1.45	1.62	1.37

[a] The VT cost-effectiveness results are expressed in 2017 dollars. The analysis assumed 62% of annual costs and savings

Persistence Analysis

Assumptions about savings persistence and measure life are important determinants of program cost-effectiveness. Unlike for many energy efficiency improvements such as high-efficiency furnaces and LEDs, measure life for HERs and other behavior-based treatments is not well-established. Presently, EVT assumes a one-year measure life for HERs, which means that HERs only produce savings in the year the reports are delivered. Most other administrators of HER programs also assume a one-year measure life. Table 26 shows measure life assumptions for different HER programs of electric utilities and whether the measure life assumption was determined based on an analysis of utility customer consumption.

Table 26. Home Energy Reports Measure Life Assumptions

Program Administrator	Measure Life Assumption (Years)	Verification of Measure Life Assumption Based on Consumption Analysis?
Ameren Illinois	1	No
Avista Utilities	3	No
Delmarva Power & Light	1	No
DTE Energy	1	No
Efficiency Vermont	1	No
Hawaii Energy Company	1	No
Pepco Maryland	1	No
Puget Sound Energy	10	Yes
Salt River Project	1	No

Source: 2018 Consortium for Energy Efficiency Behavior Program Summary. Public version available online at: https://library.cee1.org/content/2018-behavior-program-summary-public-version.

Most program administrators assume a one-year measure life for HERs, and only Puget Sound Energy undertook a study to verify its measure life assumption.

Savings Persistence Studies

Although most program administrators assume a one-year measure life for HERs, many studies have established that HER savings persist after treatment ends. These studies used RCTs to estimate annual rates of savings decay. Evaluators randomly assigned a subset of treatment group customers to a suspense group and compared the electricity savings of customers who continued to receive reports with those whose reports were suspended.

Khawaja and Stewart (2014) surveyed four RCT studies of six HERs programs and found significant variance in estimated average annual savings decay rates (ranging from 11% to 83%) and that the average rate of savings decay after treatment ends is approximately 20%. This average rate of savings decay implies a HER measure life of five years.

In an analysis of the Commonwealth Edison HER program, Sierzchula and Dinsmoor (2017) found average annual savings decay rates of between 9% and 30% depending on the length of treatment, which implies a measure life of between two and five years.[33] Ashby et al. (2017) surveyed several other

[33] Sierzchula, Will and Derek Dinsmoor, 2017. ComEd Home Energy Report Program Decay Rate and Persistence Study – Year Three. Navigant Report prepared for Commonwealth Edison Company. Available at: http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/Final_ComEd_Studies/ComEd_HER_Year_Three_Persistence_and_Decay_Study_2017-11-14.pdf

HER savings persistence studies and found that savings persist for between six months and four years after treatment ends.[34] Table 27 shows estimates of HER savings persistence from recent studies.

Table 27. Estimated Home Energy Reports Savings Persistence

Utility Service Area	Length of Treatment (Months)	Estimated Average Annual Savings Decay Rates	Implied Approximate Measure Life (Years)[a]
Upper Midwest[b]	26	21%	5
West Coast I[b]	29	18%	5
West Coast II[b]	34	15%	7
Connecticut Light & Power[c]	6	83%	1
Sacramento Municipal Utility District[d]	27	32%	3
Puget Sound Energy[e]	36	11%	10
Commonwealth Edison[f]	36	35%–65%	2-3

[a] Author's calculation based on measure life formula in Khawaja and Stewart (2014).
[b] Allcott and Rogers (2014). The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." American Economic Review, 104 (10): 3003-37.
[c] NMR Group, Tetra Tech, and Allcott (2013). Evaluation of the Year 1 Connecticut Light and Power Pilot Customer Behavior Program.
[d] Integral Analytics with BuildingMetrics Incorporated and Sageview (2012). Impact & Persistence Evaluation Report: Sacramento Municipal Utility District Home Energy Report Program.
[e] DNV-GL (2014). Home Energy Report Program: 2013 Impact Evaluation. Prepared for Puget Sound Energy.
[f] Sierzchula, Will and Derek Dinsmoor (2017). ComEd Home Energy Report Program Decay Rate and Persistence Study – Year Three.

In addition to showing that HER savings persist after treatment ends, Khawaja and Stewart (2014) and Sierzchula and Dinsmoor (2017) show that persistence depends on the frequency (number of reports per customer per year) and duration of treatment (number of years customers received reports). Estimated savings decay rates suggest that customers who are treated for longer periods of time and more frequently experience less savings decay. Also, a significant share of HER savings persistence may be attributable to lasting energy efficiency improvements such as adding insulation and adopting more efficient appliances. Brandon et al. (2017) found that 35% to 55% of HERs savings may be due to physical capital improvements.[35]

Since the beginning of the RCBS Pilot, EVT has not conducted a savings persistence study to estimate HER measure life. Such a study would require EVT to stop report delivery for a minimum of 6,000 -

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34 Ashby, Kira, Vincent Gutierrez, Steven Menges, and Jim Perich-Anderson, 2017. Keep the Change: Behavioral Persistence in Energy Efficiency Programs. Paper presented at the 2017 International Energy and Policy Evaluation Conference (Baltimore). Available at: http://www.iepec.org/2017-proceedings/polopoly_fs/1.3718071.1502993443!/fileserver/file/796588/filename/085.pdf

35 Brandon, Alec et al. "Do the Effect of Social Nudges Persist? Theory and Evidence from 38 Natural Field Experiments." Working paper. 2017.

10,000 treatment group customers, which would constitute a significant share of the RCBS Pilot treatment group population.

EVT's pause in delivering HERs in 2015 provides evidence that savings persist after treatment ends but also that savings do not persist for long when customers have been treated for less than one year. In March 2015, EVT paused delivery of the HERs. Figure 5 shows that savings for Wave 1 customers were 1.2% in April and 0.9% in May, clearly demonstrating that savings persisted after treatment ended. However, savings decayed quickly, reaching a low of 0.4%, and became statistically indistinguishable from 0% in August 2015. The average monthly rate of savings decay between April and August was 22%. If EVT had not resumed delivery in August and with this rate of monthly savings decay, the RCBS Pilot would have ceased to save electricity by April 2016. In fact, when report delivery resumed in August 2015, savings quickly returned to their pre-suspension levels and continued to increase.

Applicability of Home Energy Report Measure Life Literature to the Residential Customer Behavioral Savings Pilot

The literature on HER electricity savings persistence demonstrates that HERs have a multi-year measure life. While it is reasonable to expect that the measure life of the RCBS Pilot is greater than one year, EVT should be cautious about applying the results of HER persistence studies to Vermont and should consider conducting an independent persistence study for two reasons.

- First, as Table 27 above showed, there is significant variance in estimated HER measure life for utility customers receiving HERs for two or more years, and therefore there is uncertainty about the HER measure life that would be valid for Vermont. The estimated measure life ranges between two and 10 years.
- Second, also noted above, most residential utility customers in Vermont have different electricity end uses than customers in the rest of the country. Vermont customers tend to consume less electricity on average and have significantly lower penetrations of central air conditioning and electric space heat. Because of these low penetrations, it is probable that Vermont customers derive a larger percentage of HER savings from efficient lighting applications. Both differences could cause HER measure life in Vermont to deviate significantly in either direction from HER measure life estimated for utility programs in other parts of the country.

Guidance for a Home Energy Report Measure Life Study

To develop an accurate measure life assumption for the RCBS Pilot or a large future behavior-based pilots, Cadmus recommends that EVT conduct a measure life study based on analysis of utility customer consumption data. To obtain a behavior measure life estimate, EVT would require an estimate of savings persistence, perhaps for different treatment durations (such as one year of treatment, two years of treatment, etcetera) depending on the objectives and desired rigor of the study. Khawaja and Stewart (2014) present an analytical framework for estimating behavioral measure life using savings persistence estimates and Jenkins et al. (2017) describe the implementation of this framework in Illinois through the technical reference manual process.[36]

Cadmus provides the following guidance for implementing a savings persistence study that could be used to estimate HER measure life:

1. Before the beginning of the pilot, EVT should determine whether it wants to have the option of conducting a savings persistence study. If desired, EVT should design the pilot to allow for a savings persistence study later.
2. EVT should implement the study as a RCT. Treated customers should be randomly assigned to a report continuation or suspension group, and the savings of the two groups should be measured relative to the control group then compared to estimate persistence.
3. EVT should size the continuation and suspension treatment groups appropriately to detect the expected savings before and after suspension of the reports. EVT can employ a data simulation using customer billing data or a statistical power analysis to determine the required continuation and suspension group sizes.
4. EVT should focus its research on savings persistence after customers have been treated for two or more years. Evidence from HER savings persistence indicates very rapid decay of savings for treatments lasting one year or less (NMR Group, Tetra Tech, and Allcott 2013). There is comparably greater uncertainty about savings persistence for treatment lasting at least two years.

Recommendation for Home Energy Report Measure Life Assumption

Given substantial uncertainty and lack of empirical evidence about HER measure life in Vermont, Cadmus recommends that EVT continue to assume a one-year HER measure life. While it is likely that the true HER measure life is greater than one year, there is great uncertainty about true measure life and too many differences between Vermont utility customers and customers elsewhere to assume that previous studies of other HER utility programs have validity for Vermont.

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[36] Jenkins, Cheryl, Ted Weaver, Carly Olig, Olivia Patterson, and David Brightwell, 2017. Accounting for Behavioral Persistence. A Protocol and a Call for Discussion. Paper presented at the 2017 International Energy and Policy Evaluation Conference (Baltimore). Available at: http://www.iepec.org/2017-proceedings/polopoly_fs/1.3718069.1502900919!/fileserver/file/796587/filename/086.pdf

Appendix A. Residential Customer Behavioral Savings 2017 Customer Survey Guide

Research Area	Survey Items
Energy-Saving Improvements	B1-B6
Energy-Saving Behaviors	C1-C2
Home Energy Report Recall, Readership, and Engagement (Treatment Only)	D1-D4
Demographics	E1-E5

Total Target Completes = 800

- Treatment Group (400)
  - Wave 1 and Wave 2 (330)
  - Wave 3 (70)
- Control Group (400)
  - Wave 1 and Wave 2 (330)
  - Wave 3 (70)

Interviewer instructions are in green

CATI programming instructions are in red

Answers that should not be read are in parentheses

Variables to be pulled into survey:

- Group = Treatment Group or Control Group
- Usage Band = High, Medium, or Low
- Type = Refresh or Existing

Back-up information, not to be programmed:

- **If "No – Not a convenient time," ask if respondent would like to arrange a more convenient time for us to call them back or if you can leave a message for that person.**
- **If respondent asks how long, say, "Approximately five minutes."**
- **If questioned about survey's purpose: "This survey is for research purposes only and is not a marketing call. Your responses will remain confidential and are important to the Vermont Public Service Department."**
- **If asked for a Vermont Public Service Department contact to verify the survey's authenticity, offer PSD Consumer Affairs & Public Information at 800-622-4496.**
- **Light bulb definitions:**
  Screw-in LEB bulbs are made from multiple small lights assembled into a typical bulb shape that fits in a regular light socket
  CFLs are commonly made with a glass tube bent into a spiral, resembling soft-serve ice cream, and it fits in a regular light bulb socket

A. Introduction and Screener

[ASK SECTION A TO BOTH GROUPS]

Hello. I'm **[NAME]**, calling on behalf of the Vermont Public Service Department. We are talking to utility customers in Vermont about how energy is used in the home.

A1. Are you involved in managing or paying your home's utility bills?
- 1. (Yes)
- 2. (No) **[ASK TO SPEAK WITH THE PERSON WHO IS THE DECISIONMAKER AND START AGAIN. IF NO ONE, THEN THANK AND TERMINATE.]**
- 98. (Don't know) **[ASK TO SPEAK WITH THE PERSON WHO IS THE DECISIONMAKER AND START AGAIN. IF NO ONE, THEN THANK AND TERMINATE.]**
- 99. (Refused) **[THANK AND TERMINATE]**

A2. Do you or any member of your household work for Efficiency Vermont?
- 1. (Yes) **[THANK AND TERMINATE]**
- 2. (No)
- 98. (Don't know)

A3. We are conducting an important survey today about saving energy in your home. This survey will take approximately five minutes. Your answers will remain confidential. Do you have a few minutes to help us out?
- 1. (Yes)
- 2. (No) **[THANK AND TERMINATE]**

B. Energy-Saving Improvements

[ASK BOTH GROUPS]

I would like to understand some of the things you might have done to save energy in your home during 2017.

B1. I will read you a list of energy-saving home improvements. Tell me if you have done any of the following during 2017. **[RECORD 1=YES, 2=NO, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT]**
- A. Purchased or received CFL bulbs (compact fluorescent light)
- B. Purchased or received LED bulbs (light emitting diode)
- C. Installed a programmable or smart thermostat
- D. Purchased and installed an ENERGY STAR or high-efficiency appliance
- E. Purchased and installed new heating or cooling equipment
- F. Changed the furnace filter
- G. Installed extra insulation to ceiling, ducts, walls, attic, or basement

H. Added caulking, spray foam, weather stripping, or plastic sheeting
I. Installed a water/energy-saving showerhead, faucet head, or aerator
J. Installed higher-efficiency doors or windows
K. Added solar panels to home
L. Recycled a second refrigerator

[ASK IF B1B=1]

B2. You mentioned that you purchased or received LEDs in 2017. Did you purchase these LEDs or did you receive them for free?

1. (Purchased LEDs)
2. (Received free LEDs)
3. (Both purchased and received free LEDs)
98. (Don't know) **[SKIP TO SECTION C]**
99. (Refused) **[SKIP TO SECTION C]**

[ASK IF B2=1 OR 3]

B3. How many LED bulbs did you purchase in 2017? Please count the number of individual bulbs, not the number of boxes or packs.

1. **[RECORD NUMERIC ANSWER:___________________________]**
98. (Don't know)
99. (Refused)

[ASK IF RESPONSE FROM B3>0]

B4. Of the **[INSERT RESPONSE FROM B3]** LED bulbs you purchased, how many are currently installed in your home?

1. **[RECORD NUMERIC ANSWER:___________________________]**
98. (Don't know)
99. (Refused)

[ASK IF B2=2 OR 3]

B5. How many LED bulbs did you receive for free?

1. **[RECORD NUMERIC ANSWER:___________________________]**
98. (Don't know)
99. (Refused)

[ASK IF RESPONSE FROM B5>0]

B6. Of the **[INSERT RESPONSE FROM B5]** LED bulbs you received for free, how many are currently installed in your home?

1. **[RECORD NUMERIC ANSWER:________________________]**
98. (Don't know)
99. Refused

C. *Energy-Saving Behaviors*

[ASK BOTH GROUPS]

C1. Using a scale from 0 to 10 where 0 means *extremely difficult* and 10 means *extremely easy*, how easy is it for you to save energy in your home?

1. **[RECORD AN ANSWER FROM 0-10:________________________]**
98. (Don't know)
99. (Refused)

C2. I will read through some energy-saving actions you may have heard or read about. Please let me know if you always, sometimes, or never took these actions in your home in 2017. **[RECORD 1=ALWAYS, 2=SOMETIMES, 3=NEVER, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT] [RANDOMIZE ORDER]**

A. Turned off lights in rooms that are unoccupied
B. Washed laundry in cold water
C. Unplugged electronic equipment or appliances when not in use
D. Adjusted thermostat setting on your air conditioner when leaving or sleeping
E. Took short showers
F. Turned down water heater temperature
G. Used energy-saving or sleep features of your computer **[IF RESPONDENT DOES NOT OWN A COMPUTER, MARK RESPONSE AS 99]**

D. *Home Energy Report Recall, Readership, and Engagement*

[ASK SECTION D TO TREAMENT GROUP ONLY]

D1. Our records indicate that a few times in 2017, you should have received a document in the mail called a Home Energy Report or Current Insights. This report included some energy-savings tips and some charts about your home's energy consumption. Do you recall seeing one of those reports or hearing someone in your household talking about that report?

1. (Yes)
2. (No) **[SKIP TO SECTION E]**
98. (Don't know) **[SKIP TO SECTION E]**
99. (Refused) **[SKIP TO SECTION E]**

D2. Which of the following statements best describes what you did with the last report you received? **[READ LIST]**

1. I read the report thoroughly
2. I read some of the report
3. I skimmed the report
4. I did not read the report
98. (Don't know)
99. (Refused)

D3. On a scale from 0 to 10 where 0 means *not at all important* and 10 means *very important*, how important would you say the Home Energy Reports were in prompting you to make any energy-saving improvements?

1. **[RECORD ANSWER FROM 0-10:_________________________]**
98. (Don't know)
99. (Refused)

D4. What energy-saving improvements that were suggested in the Home Energy Reports did you make? **[MULTIPLE RESPONSE]**

1. (Installed LEDs or CFLs)
2. (Installed a programmable or smart thermostat)
3. (Installed an ENERGY STAR or high-efficiency appliance)
4. (Installed new heating or cooling equipment)
5. (Changed the furnace filter)
6. (Installed extra insulation to ceiling, ducts, walls, attic, or basement ceiling)
7. (Added caulking, spray foam, weather stripping, or plastic sheeting)
8. (Installed extra insulation to ceiling or attic)
9. (Installed a water/energy-saving showerhead, faucet head, or aerator)
10. (Installed solar panels)
11. (Installed higher-efficiency doors or windows)
12. (Recycled a second refrigerator)
13. (Other **[SPECIFY:______________________]**)
14. (None; did not make any improvements suggested in the reports)
98. (Don't know)
99. (Refused)

D5. Overall, how satisfied are you with the Home Energy Reports? Please use a scale from 0 to 10 where 0 means *extremely dissatisfied* and 10 means *extremely satisfied*.

1. **[RECORD ANSWER FROM 0-10:_________________________]**
98. (Don't know)
99. (Refused)

E. Demographics

[ASK SECTION I TO BOTH GROUPS]

Finally, I have a few questions about your home and household.

E1. What type of building is your home? Is it a… [READ LIST]
1. Detached single-family home
2. Two-family building or duplex
3. Three or four family building
4. Part of a building with five or more units
5. (Other [SPECIFY: _________________________])
98. (Don't know)
99. (Refused)

E2. Do you own or rent this home?
1. (Own/buying)
2. (Rent/lease)
3. (Other [SPECIFY: _________________________])
98. (Don't know)
99. (Refused)

E3. What is the approximate square footage of the finished living space of your home? Do not include unheated garages, attic, or basement space. Is it… [READ LIST]
1. Less than 800 square feet
2. 800 to 1,199 square feet
3. 1,200 to 1,599 square feet
4. 1,600 to 1,999 square feet
5. 2,000 to 2,499 square feet
6. 2,500 to 2,999 square feet
7. 3,000 to 3,999 square feet
8. 4,000 to 4,999 square feet
9. 5,000 or more square feet
98. (Don't know)
99. (Refused)

E4. Does your household have an electric car?
1. (Yes)
2. (No)
98. (Don't know)
99. (Refused)

E5. Respondent's gender **[RECORD, BUT DO NOT ASK]**

1. Male
2. Female

F. Closing

That is the end of the survey. The Vermont Public Service Department appreciates you for taking time to respond. Thank you. Have a nice day!